SAMI BOOK

IN

Chemistry

General Secondary Certificate

Graduated Exams

With

The model Answers

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مدونة اي بوك التعليمية
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Index of Topics

Page number column header spans Chapter, Exam, Answer.

Marks of the final exam

Chapters	Subjects	Mark
Chapter (1)	Transition elements	11.5
Chapter (2)	Chemical analysis	10.5
Chapter (3)	Chemical equilibrium	12
Chapter (4)	Electrochemistry	12
Chapter (5)	Organic chemistry	29
Total marks		**75 Marks**
The student should choose (4) questions x 15 marks = 60 marks		

MY BEST WISHES

Answer four only of the following questions:

Question (1)

A) Choose the correct answer:-

1- The elements of the first transition series lies in ......

a) period (3)   b) period (4)   c) period (5)   d) period (6)

2- The element which is used in galvanization of steel is ....

a) titanium   b) vanadium   c) scandium   d) zinc

3- Acids are kept in containers made of ......

a) nickel   b) copper   c) vanadium   d) cobalt

4- All the following are transition element except ......

a) manganese   b) copper   c) Zinc   d) cobalt

5- The maximum value of oxidation state in the elements of the first transition series occurs in..........

a) Vanadium   b) Chromium   c) Manganese   d) Iron

6-The compound $FeCl_3$ is ......

a) paramagnetic and coloured.   b) diamagnetic and coloured.

c) paramagnetic and colourless.   d) diamagnetic and colourless.

B) The electronic configuration of chromium ion Cr^{3+} is [Ar], $3d^3$:

1- Write the electronic configuration of chromium atom.

2- What is the maximum oxidation state of chromium?

3- Why does chromium resist the atmospheric factors, although its chemical activity?

C) 1) Which element is more easily to be oxidized ($_{25}Mn$) or ($_{26}Fe$)? Say why?

2) Which element can form a compound with Cl_2, its formula is MCl_4?

($_{29}Cu$, $_{26}Fe$, $_{22}Ti$) say why?

Question (2)

A) What is the role of:

1- Chromium metal in plating other metals.

2- Nickel in hydrogenation reactions.

3- Cobalt - 60 in medical applications.

4- Vanadium pent oxide in the production of sulphuric acid.

B) Mention one use for:

1- Manganese II sulphate.   2- Radioactive cobalt – 60.

3- Potassium permanganate.   4- Vanadium pent oxide.

5- Zinc sulfide.   6- Copper (II) sulphate.

C) How is Fehling solution used for detection of glucose?

Question (3)

A) Choose the electronic structure from column (B) of the element in column (A) and its use from column (C):

(A) Element	(B) Electronic Structure	(C) Uses
1- Titanium $_{22}Ti$	a- [Ar] $3d^{10},4s^1$	I- one of its compounds is used as an oxidizing agent and as an antiseptic.
2- Chromium $_{24}Cr$	b- [Ar] $3d^7,4s^2$	II- it is used in hydrogenation of oils.

3- Manganese $_{25}$Mn	c- [Ar] 3d^2, 4s^2	III- Its radioactive isotope (60) is used in preservation of foods.
4- Cobalt $_{27}$Co	d- [Ar] 3d^8,4s^2	IV- It is used in leather tanning.
5- Nickel $_{28}$Ni	e- [Ar] 3d^5,4s^1	V- Its alloys with aluminum are used in manufacture of space ships
6- Copper $_{29}$Cu	f- [Ar] 3d^5,4s^2	VI- It is used in structure of Fehling solution.
		VII- It is used in manufacture of car springs

B) Give reasons for :-

1- Chromium and copper are abnormal from the expected electronic configuration.
2- Transition elements have different oxidation states.
3- The elements of the first transition series have high melting and boiling points.
4- The transition elements have ideal catalytic activity.
5- Titanium is used in dental implants and artificial joints.

C) Ammonia gas has a pungent odour, colourless and fairly soluble in water.

1- Write the equation of preparation of ammonia in industry, and mention the conditions of reaction.
2- What is the name of the method used in preparation of ammonia in industry?
3- What is the catalyst used in this method? Mention its role.

Question (4)

A) Compare between: Paramagnetic and diamagnetic substances.

B) Classify the following to diamagnetic or paramagnetic substances:

$CoCl_2$, $Fe_2(SO_4)_3$, $ZnSO_4$, $Cu(NO_3)_2$, $FeCl_2$
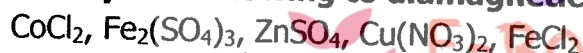
C) Write the scientific term

1- Elements which are filled successively with electrons in their 3d sublevel.
2- The number of unpaired electrons in the atomic orbital in the sublevel (d).
3- A compound used in making illuminating paints and x-ray screens.
4- Substance which accelerate some chemical reactions.
5- The element that has an incompletely filled (d) or (F) sublevels in either the free state or in one of its oxidation state.

Question (5)

A) From the corresponding graph:

a- **Redraw the graph,** illustrating the activation energy on it.
1- Before adding the catalyst.
2- After adding the catalyst.

b- What is the catalyst used in this reaction?

c- Write the equation that expresses this reaction.

Energy

$2H_2O_2$

$2H_2O+O_2$

Path of the reaction

B) What is meant by:

1- Transition element .
2- Paramagnetic property.
3- Diamagnetic property.
4- The magnetic moment.

C) Classify the following to coloured or colourless substances:

1- Iron (II) ion.
2- Iron (III) ion.
3- Titanium (III) ion.
4- Scandium (III) ion.
5- Copper (II) ion.
6- Zinc (II) ion.

Answer of Question (1)

A)	1	2	3	4	5	6
	b	d	a	c	c	a

B) 1- $_{24}Cr$: [Ar], $4s^1$, $3d^5$

2- (+6)

3- This is due to formation of a non porous layer of chromium oxide on its surface, which prevents further reaction with oxygen of the air.

C) 1- ($_{26}Fe$) is easier to be oxidized than (Mn^{3+}). This due to:

The electronic configuration of an iron atom is: $_{26}Fe$: [Ar] $4s^2$, $3d^6$

Fe^{2+}: $3d^6$ Fe^{3+}: $3d^5$

(d^6) less stable   Half- filled (d^5) more stable

So, it is easy to obtain iron III

But in case of manganese atom the electronic configuration is $_{25}Mn$: [Ar] $4s^2$, $3d^5$

Mn^{2+}: $3d^5$ Mn^{3+}: $3d^4$

Half- filled (d^5) more stable   (d^4) less stable

So, it is difficult to obtain Mn (III).

2- Titanium (Ti_{22}) because it is more stable in oxidation state (+4).

Answer of Question (2)

A) 1- **The role of chromium metal in plating other metals:** protects the metals from oxidation, corrosion and gives them attractive appearance.

2- **The role of nickel in hydrogenation reactions:** is used as a catalyst

3- **The role of cobalt - 60 in medical applications:** is used for diagnosis and treatment of tumors (cancer).

4- **The role of vanadium pent oxide (V_2O_5) in the production of sulphuric acid:** is used as a catalyst.

B) 1- **Manganese II sulphate** is used as fungicides

2- **Radioactive cobalt - 60** is used for diagnosis and treatment of tumors (cancer).

3- **Potassium permanganate** is used as an oxidizing agent and as an antiseptic.

4- **Vanadium penta oxide** is used as a catalyst and manufacture of strong magnetic conductors.

5- **Zinc sulfide** is used in making illuminating paints and x-ray screens.

6- **Copper (II) sulphate** is used in Fehling solution. *insecticides and fungicide in purific the drinka water.*

C) On adding Fehling solution to glucose, the colour of Fehling solution changes from blue to orange.

Answer of Question (3)

A) 1- with (c) with (V).   2- with (e) with (IV).   3- with (f) with (I).

4- with (b) with (III).   5- with (d) with (II).   6- with (a) with (VI).

B) 1- This is because chromium atom has more stability when it has half-filled sublevel

$4s^1$, $3d^5$, and copper atom has more stability when it has half-filled sublevel ($4s^1$) and completely filled sublevel ($3d^{10}$).

2- This is because 4s and 3d sublevels have close energy, on ionization the atom starts to lose electrons from 4s then from 3d in sequence.

3- This is because they have strong metallic bonds due to the increase of the valence electrons in both the (4s) and (3d) sublevels.

4- This is because the unpaired electrons of d-sublevels make bonds with reactants on the surface. So, concentration of the molecules increases and the rate of chemical reaction increases too.

5- Because, it is inert substance so the body does not eject it and does not cause any type of common poisoning.

C) 1- $N_2(g)$ + $3H_2(g)$ $\xrightarrow[500\,°C\,/600\,atm]{Fe}$ $2NH_3(g)$

2- Haber - Bosh method.

3- The catalyst used in this method is called divided iron.

   - The catalyst increases the rate of chemical reaction without itself being changed.

Answer of Question (4)

A) Paramagnetic substance	Diamagnetic substance
1. It is the substance that is attracted to the magnetic field.	1. It is the substance that is repelled with the magnetic field.
2. The elements or their compounds have unpaired electrons in their orbitals	2. The elements or their compounds have paired electrons in all their orbitals
3. The magnetic moment of the element does not equal zero.	3. The magnetic moment of the element equals zero.
4. Examples: Fe (d^6), Cu (d^9)	4. Examples: Zn (d^{10})

B) $CoCl_2$, $Fe_2(SO_4)_3$, $ZnSO_4$, $Cu(NO_3)_2$, $FeCl_2$ are paramagnetic substances.
   $ZnSO_4$ is a diamagnetic substance.

C) 1- First transition series.   2- Magnetic moment.
   3- Zinc sulphide.   4- Catalyst.
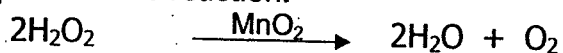   5- Transition elements.

Answer of Question (5)
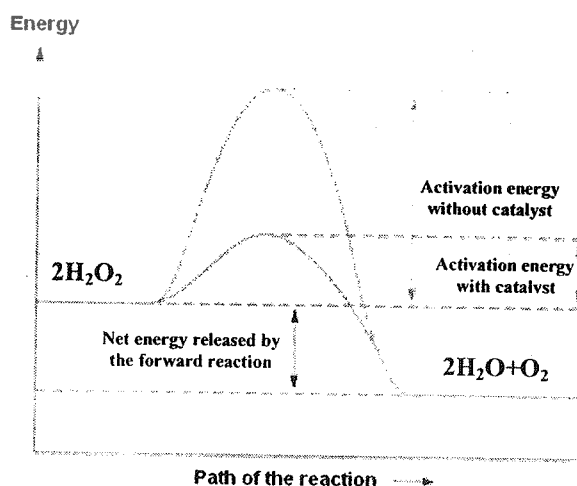
A) a-

b- The catalyst used is manganese dioxide (MnO_2).

c- The equation that expresses this reaction.

$$2H_2O_2 \xrightarrow{\;MnO_2\;} 2H_2O + O_2$$

B) 1- The transition element is the element which possesses an incompletely filled (d) or (f) sublevel either in free state or in one of its ions.

2- **Paramagnetic property** is the attraction of the substance to the magnetic field.

3- **Diamagnetic property** is the repulsion of the substance from the magnetic field.

4- **The magnetic moment** is the number of unpaired electrons in d- sublevel.

C) 1- Iron (II) ion is (coloured).   2- Iron (III) ion is (coloured).

3- Titanium (III) ion (coloured).   4- Scandium (III) ion is (colourless).

5- Copper (II) ion is (coloured).   6- Zinc (II) ion is (colourless).

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Chemistry

Graduated Exams with the model answers

Examinations of General Secondary Certificate

with the model answers

Answer four only of the following questions:

Question (1)

A) Choose the correct answer :

1. Reducing magnetic iron oxide from 400 – 700 °C gives ....
   a) Fe   b) FeO   c) Fe_2O_3 d) $FeSO_4$

2. On passing hot steam over red hot iron, it gives .... and hydrogen.
   a) Fe_3O_4 b) Fe_2O_3 c) FeO   d) $Fe(OH)_2$

3. The reducing agent in Midrex furnace is ......
   a) $CO_2 + H_2$ b) CO   c) $CO + H_2$ d) H_2

4. Iron element is found free in ......
   a) earth`s crust        b) volcanoes        c) earth` core   d) meteorites

5. Black iron oxide is a mixed oxide, it reacts with conc. hot acids giving ......
   a) iron II salts.   b) iron III salts.   c) (a and b) together.   d) iron III oxide.

6. Heating iron (II) sulphate, produces iron (III) oxide, sulphur dioxide and......
   a) hydrogen   b) water
   c) sulphur trioxide   d) hydrogen sulphide

B) Give reasons for :

1- Metals are used industrially as alloys and not as pure metal.
2- Concentrated nitric acid causes passivity to iron.
3- Copper with gold from a substitutional alloy.
4- $FeCl_2$ is formed when hot iron reacts with hydrogen chloride gas, while $FeCl_3$ is formed when hot iron reacts with chlorine gas.
5- When iron II oxalate is heated in the absence of air, iron II oxide is formed and not iron III oxide.

C) What is the effect of sulphuric acid on:

1- iron under the different conditions.   2- iron II oxide
3- iron III oxide.   4- Magnetic iron oxide.

Question (2)

A) Explain the role of each of the following :

1. Natural gas in Midrex furnace.
2. Coke in the blast furnace.

B) What is the effect of heat on:

1- iron II oxalate.   2- iron II sulphate.
3- iron III hydroxide.   4- iron carbonate.

C) What is meant by each of the following:

1- Sintering process.   2- Roasting process.
3- The alloy.   4- Passivity of the metal.

Question (3)

A) Write scientific term for each of the following :

1. The process in which fine iron ore particles are collected to obtain larger ones.
2. Alloy formed when its elements are combined chemically.
3. Strongly heating iron ore in air to be dried and get rid of humidity.

4. The furnace which uses carbon monoxide gas to reduce haematite.

5- The process of obtaining ore in small sizes suitable to be easily reduced.

B) Explain by chemical equations, How can you obtain the following:

1. iron **III** oxide from iron **II** oxalate.

2. iron **III** hydroxide from iron.

3. iron **III** oxide from siderite.

4. iron **II** oxide from iron.

C) Prove that: Magnetic iron oxide (Fe_3O_4) is a mixed oxide

Question (4)

A) Explain the following by balanced chemical equation :

1. Heating black iron oxide in air.

2. Heating iron **III** hydroxide above 200 °C.

3. Heating iron **II** sulphate.

4. Strongly heating of iron **II** oxalate in absence of air.

5. Reaction of black iron oxide with hot conc. sulphuric acid.
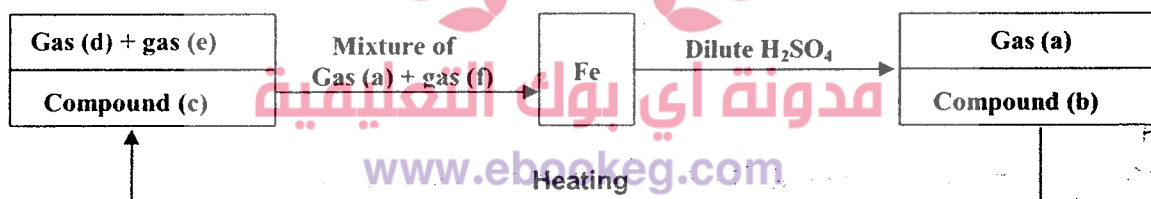
B) Compare between :

1- Blast furnace and Midrex furnace in view of:

 a) The charge. b) The reducing agent. c) The iron produced.

2- Magnetite and siderite according to

 a) The scientific name. b) The chemical formula.

3- Interstitial alloy and substitutional alloy.

C) Write the chemical equation for the reaction of hot conc. Sulphuric acid with iron metal.

Question (5)

A) Copy the following diagram in your sheet and then answer the following questions:

Gas (d) + gas (e)	Mixture of		Dilute H_2SO_4	Gas (a)
Compound (c)	Gas (a) + gas (f)	Fe	→	Compound (b)

Heating

1. Mention the names of substances a, b, e, f

2. Write the chemical equations representing the reactions in the diagram.

3. What is name of the furnace used in converting compound (c) to iron, and what is the type of the iron produced?

B) If you have the following substances: iron fillings - dilute HCl - conc. H_2SO_4 - ammonia solution - sulphur - source of heat - water.

How can you obtain the following and write the balanced chemical equations:

1. Sulphur dioxide. 2. iron III oxide. 3. iron II chloride.

4. iron II hydroxide. 5. iron II sulphide.

C) How can you differentiate between:

1- Dilute H_2SO_4 and conc. H_2SO_4 by iron fillings.

2- Dilute HNO_3 and conc. HNO_3 by iron fillings.

3- (Cu + Zn) alloy and (Fe + Zn) alloy.

4- iron II sulphate and iron III chloride.

Answer of Question (1)

A) 1	2	3	4	5	6
b	a	c	d	c	c

B) 1- This is because the alloys have new properties different from those of the pure metals such as: 1. The alloys are harder than the pure metal.

2. The alloys resist rust and corrosion.

3. The alloys can be shaped.

4. The alloys increase the melting point.

5. The alloys increase electric conductivity and magnetic properties.

5. The alloys increase malleability and ductility.

2- Due to the formation of a thin layer of oxide which protects the metal from further reaction. This layer can be removed by dissolving with dilute hydrochloric acid.

3- This is because all the atoms of the alloy have the same diameter, the same chemical properties and the same crystalline structure
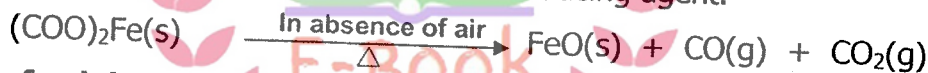
4- $FeCl_2$ is formed due to the formation of hydrogen (reducing agent) which prevents the formation of iron (III) chloride.

$$Fe(s) + 2HCl(aq) \longrightarrow FeCl_2(s) + H_2(g)$$

while $FeCl_3$ is formed because chlorine is a strong oxidizing agent.

$$2Fe(s) + 3Cl_2(g) \longrightarrow 2FeCl_3(s)$$

5- Because the produced carbon monoxide is a reducing agent.

$$(COO)_2Fe(s) \xrightarrow[\Delta]{\text{In absence of air}} FeO(s) + CO(g) + CO_2(g)$$

C) 1- Effect of sulphuric acid on iron under the different conditions:

$$Fe(s) + H_2SO_4(aq) \xrightarrow{\text{Dil.}} FeSO_4(aq) + H_2(g)$$

$$3Fe(s) + 8H_2SO_4(\ell) \xrightarrow[\Delta]{\text{Conc.}} FeSO_4(aq) + Fe_2(SO_4)_3(aq) + 4SO_2(g) + 8H_2O(v)$$
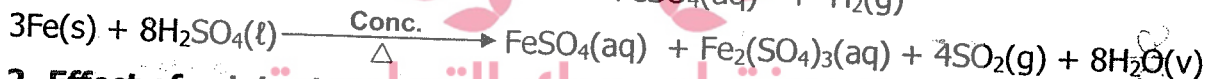
2- Effect of sulphuric acid on iron II oxide:

$$FeO(s) + H_2SO_4(\ell) \xrightarrow{\text{Dil.}} FeSO_4(aq) + H_2O(\ell)$$

3- Effect of sulphuric acid on iron III oxide:

$$Fe_2O_3(s) + 3H_2SO_4(aq) \xrightarrow[\Delta]{\text{Conc.}} Fe_2(SO_4)_3(aq) + 3H_2O(\ell)$$

4- Effect of sulphuric acid on Magnetic iron oxide:

$$Fe_3O_4(s) + 4H_2SO_4(\ell) \xrightarrow[\Delta]{\text{Conc.}} FeSO_4(aq) + Fe_2(SO_4)_3(aq) + 4H_2O(\ell)$$
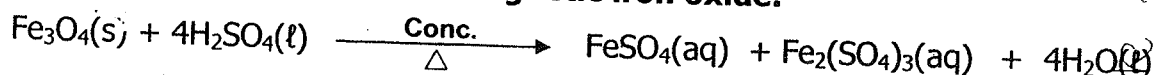
Answer of Question (2)

A) 1- The reducing agent is prepared from natural gas by passing the natural gas (93% methane) with carbon dioxide and steam in special converters containing a catalyst.

$$2CH_4 + CO_2 + H_2O \xrightarrow{\text{Heat}} 3CO + 5H_2$$
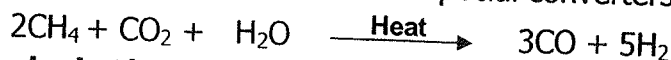
2- The role of coke in the blast furnace [Reduction process]:

$$C + O_2 \xrightarrow{\Delta} CO_2$$

$$CO_2 + C \xrightarrow{\Delta} 2CO$$

$$3CO + Fe_2O_3 \xrightarrow{\text{Over } 700\,^0C} 2Fe + 3CO_2$$
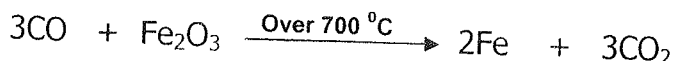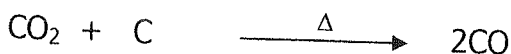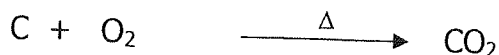
B) 1- Effect of heat on iron II oxalate:

$$\begin{array}{c} COO \\ | \\ COO \end{array}\!\!\!\Big\rangle Fe_{(s)} \xrightarrow[\Delta]{\text{In absence of air}} FeO(s) + CO(g) + CO_2(g)$$

2- Effect of heat on iron II sulphate:

$$2FeSO_4(s) \xrightarrow{\Delta} Fe_2O_3(s) + SO_2(g) + SO_3(g)$$
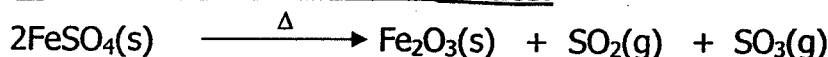
3- Effect of heat on iron III hydroxide:

$$2Fe(OH)_3(s) \xrightarrow{\text{Over } 200^0C} Fe_2O_3(s) + 3H_2O(v)$$

4- Effect of heat on iron carbonate:

$$FeCO_3(s) \xrightarrow{\Delta} FeO(s) + CO_2(g)$$

C) 1- Sintering process: is changing the fine particles of iron ore into larger ones to be easily reduced.

  2- Roasting process: is heating the iron ore strongly in air to get rid of humidity and impurities.

  3- The alloy: is fused of two metals or more by a fixed ratio. (Non-metals may be used).

  4- Passivity of metal: is the formation of a thin layer of oxide which protects the metal from further reaction.

Answer of Question (3)

A) 1- Sintering process.   **2-** Inter-metallic alloy.
  3- Roasting process.   **4-** Blast furnace.
  5- Cracking process.

B) 1. Obtaining iron III oxide from iron II oxalate:
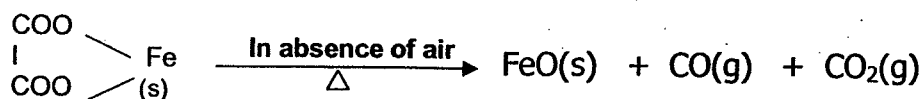
$$(COO)_2Fe \xrightarrow[\Delta]{\text{In absence of air}} FeO + CO + CO_2$$

$$4FeO + O_2 \xrightarrow{\Delta} 2Fe_2O_3$$

2. Obtaining iron III hydroxide from iron:

$$2Fe + 3Cl_2 \xrightarrow{\Delta} 2FeCl_3$$

$$FeCl_3 + 3NaOH \longrightarrow 3NaCl + Fe(OH)_3$$

3. Obtaining iron III oxide from siderite:

$$2FeCO_3 \xrightarrow{\Delta} 2FeO + 2CO_2$$

$$4FeO + O_2 \xrightarrow{\Delta} 2Fe_2O_3$$
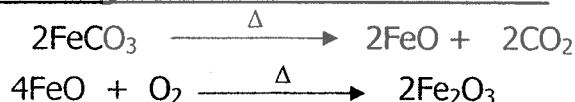
4. Obtaining iron II oxide from iron:

$$3Fe + 2O_2 \xrightarrow{\Delta} Fe_3O_4$$

$$Fe_3O_4 + H_2 \xrightarrow{400 - 700\,\dot{C}} 3FeO + H_2O$$
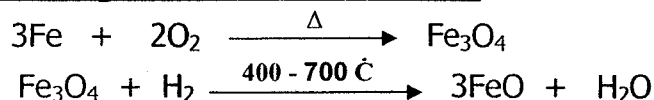
C) Magnetic iron oxide **(Fe₃O₄)** is a mixed oxide of (FeO + Fe₂O₃) because when it reacts with hot concentrated sulphuric acid gives two salts (iron (II) sulphate and iron (III) sulphate) as follows:

$$Fe_3O_4(s) + 4H_2SO_4(\ell) \xrightarrow[\Delta]{\text{Conc.}} FeSO_4(aq) + Fe_2(SO_4)_3(aq) + 4H_2O(\ell)$$
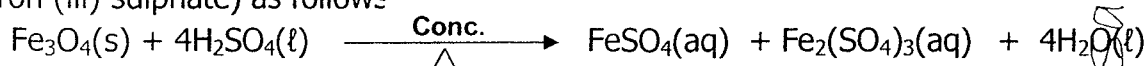
Answer of Question (4)

A) 1. Heating black iron oxide in air:
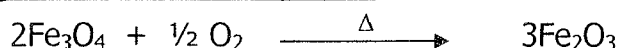
$$2Fe_3O_4 + \tfrac{1}{2} O_2 \xrightarrow{\Delta} 3Fe_2O_3$$

2. Heating iron III hydroxide above 200 °C:

$$2Fe(OH)_3 \xrightarrow{\text{Over } 200^0C} Fe_2O_3 + 3H_2O$$

3. Heating iron II sulphate:

$$2FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2 + SO_3$$

4. Strongly heating of iron II oxalate in absence of air:

$$(COO)_2Fe \xrightarrow[\Delta]{\text{In absence of air}} FeO + CO + CO_2$$

5. Reaction of black iron oxide with hot conc. Sulphuric acid:

$$Fe_3O_4 + 4H_2SO_4 \xrightarrow[\Delta]{\text{Conc.}} FeSO_4 + Fe_2(SO_4)_3 + 4H_2O$$

B) 1. Points of comparison	Blast furnace	Midrex furnace
The charge	Haematite + coke + lime stone	Haematite
The reducing agent	CO	CO+H$_2$
The iron produced	Pig iron	Spongy iron

2. Points of comparison	Magnetite	Siderite
The scientific name	Magnetic iron oxide	Iron (II) carbonate
The chemical formula	Fe$_3$O$_4$	FeCO$_3$

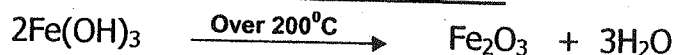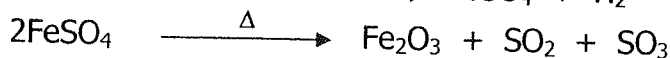| 3. Interstitial Alloys	Substitution alloys
1. It is formed when a metal is introduced to another pure metal to form an alloy	1. It is formed when some of the atoms of the crystal lattice of the pure metal are replaced by the atoms of the metal added
2. This takes place when the atoms of the metals added are smaller or larger than the spaces of the pure metal.	2. This takes place when all the atoms of the alloy have the same diameter, the same chemical properties and the same crystalline structure.
Examples: iron- carbon alloy	Examples: 1. Copper-gold alloy. 2. iron-nickel alloy. 3. iron-chromium alloy. 4. Ferromanganese alloy

C)
$$3Fe + 8H_2SO_4 \xrightarrow[\Delta]{\text{Conc.}} FeSO_4 + Fe_2(SO_4)_3 + 4SO_2 + 8H_2O$$

Answer of Question (5)

A) 1. a = hydrogen b = iron II sulphate c = iron III oxide
   d = sulphur dioxide e = sulphur trioxide f = carbon monoxide

2. The chemical equations:

$$Fe + H_2SO_4 \xrightarrow{\text{Dil.}} FeSO_4 + H_2$$

$$2FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2 + SO_3$$

$$2 Fe_2O_3 + 3CO + 3H_2 \longrightarrow 4Fe + CO_2 + 3H_2O$$
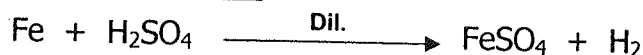
3. The name of the furnace used to in converting the compound (C) to iron is Midrex furnace. The type of the iron produced is spongy iron

B) 1. Obtaining sulphur dioxide:

$$3Fe + 8H_2SO_4 \xrightarrow[\Delta]{\text{Conc.}} FeSO_4 + Fe_2(SO_4)_3 + 4SO_2 + 8H_2O$$

2. Obtaining iron III oxide:

$$Fe + H_2SO_4 \xrightarrow{\text{Dil.}} FeSO_4 + H_2$$
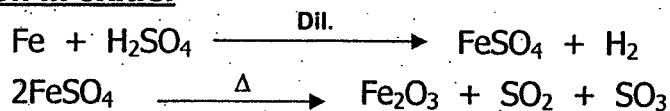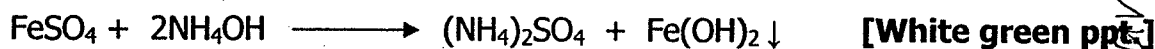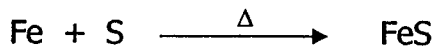
$$2FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2 + SO_3$$

3. Obtaining iron II chloride:

$$Fe + 2HCl \xrightarrow{\text{Dil.}} FeCl_2 + H_2$$

4. Obtaining iron II hydroxide:

$$FeSO_4 + 2NH_4OH \longrightarrow (NH_4)_2SO_4 + Fe(OH)_2 \downarrow \quad \textbf{[White green ppt.]}$$

5. Obtaining iron II sulphide:

$$Fe + S \xrightarrow{\Delta} FeS$$

C) 1- Differentiation between Dilute H_2SO_4 and conc. H_2SO_4 by iron fillings.

By adding iron fillings to each of them:
- If it gives hydrogen gas which is burnt by a pop sound, so it is dilute H_2SO_4.
- If it gives sulphur dioxide gas which turns a paper wetted with acidified potassium dichromate from orange to green, so it is conc. H_2SO_4.

$$Fe(s) + H_2SO_4(aq) \xrightarrow{\text{Dil.}} FeSO_4(aq) + H_2(g)\uparrow$$

$$3Fe(s) + 8H_2SO_4(\ell) \xrightarrow[\Delta]{\text{Conc.}} FeSO_4(aq) + Fe_2(SO_4)_3(aq) + 4SO_2(g\uparrow + 8H_2O(v)$$
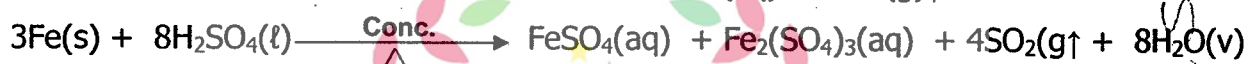
2- Differentiation between Dilute HNO_3 and conc. HNO_3 by iron fillings.

By adding iron fillings to each of them:
- If the iron fillings react with the acid, so it is dilute HNO_3.
- If the iron fillings do not react with the acid, so it is conc. HNO_3 (passivity of the metal).

3- Differentiation between (Cu + Zn) alloy and (Fe + Zn) alloy.

By adding dilute hydrochloric acid to each of them:
- If the whole alloy dissolves in the acid, so the alloy is (Fe + Zn) alloy.
- If a red metal (Cu) precipitates, so the alloy is (Cu + Zn) alloy.

4- Differentiation between iron II sulphate and iron III chloride.

By adding sodium hydroxide solution to the solution of each of them.

$$FeSO_4(aq) + 2NaOH(aq) \longrightarrow Na_2SO_4(aq) + Fe(OH)_2(s)\downarrow \quad \text{[White green ppt.]}$$

$$FeCl_3(aq) + 3NaOH(aq) \longrightarrow 3NaCl(aq) + Fe(OH)_3(s)\downarrow \quad \text{[reddish brown ppt.]}$$

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Exam (3) on qualitative analysis

Answer four questions only of the following:

Question (1)

A) Choose number of the correct answer of the following cases:

a) Salt solution + Barium chloride solution gives white precipitate does not dissolve in acids:

  a) nitrate.   b) phosphate.   c) sulphate.   d) nitrite.

b) Salt solution + lead (II) acetate solution gives black precipitate:

  a) sulphate.   b) nitrate.   c) phosphate   d) sulphide

c) Salt solution + sodium hydroxide solution gives reddish brown precipitate:

  a) copper (II)   b) iron (III)   c) aluminum   d) iron (II)

d) Solid solution + hydrochloric acid gives a pungent gas and a yellow precipitate:

  a) sulphide   b) carbonate   c) thiosulphate   d) sulphite.

B) When a solution of sodium hydroxide is added to three salts of chloride solutions the following results appears:

The first: white gelatinous precipitate.

The second: reddish brown precipitate.

The third: greenish white precipitate.

Mention the basic radical for each one of the three salts, and write the equations of the reactions.

C) Illustrate by balanced symbolic equations, how you can differentiate between each pair of the following salts:

a) Sodium sulphite and sodium sulphate.

b) iron (II) chloride and iron (III) chloride.

Question (2)

(A) Choose from column (B) what is suitable from column (A) on adding silver nitrate solution to the solutions of some anions and a precipitate is formed:

(A)	(B)
1) phosphate 2) bromide 3) chloride 4) sulphide	a. black ppt., does not dissolve in conc. ammonia solution. b. white ppt., dissolves in conc. ammonia solution. c. yellowish white ppt., dissolve slowly in conc. ammonia solution. d. yellow ppt., dissolves in conc. ammonia solution. e. yellow ppt., dissolves in dilute nitric acid and ammonia solution.

B) Mention the name and formula of the acidic radical or basic radical which gives the following results when we test for it.

a) Salt solution + sodium hydroxide solution gives greenish white precipitate.

b) Salt solution + magnesium sulphate solution gives white precipitate after heating.

c) Salt solution + silver nitrate solution gives yellow precipitate does not dissolve in ammonia solution.

C) Dilute hydrochloric acid is added to three solid salts of sodium metal, the following observations appear:

The first: a gas evolves which has irritating smell and turns a paper wet with acidified potassium dichromate from orange to green.

The second: a colorless gas evolves and turns into reddish brown at the top of the tube.

The third: a colorless gas evolves and a yellow precipitate is formed.

Mention the acidic radicals for the three salts, and write the equations of the reaction.

Question (3)

A) Give reasons illustrating your answers with symbolic equations if it is possible:

a) When sodium hydroxide solution is added gradually to aluminum chloride solution, a gelatinous white precipitate is formed which dissolves on adding excess reagent

b) Dilute hydrochloric acid is not used to differentiate between salts of sodium carbonate or sodium bicarbonate.

c) The violet colour of acidified potassium permanganate disappears on adding sodium nitrite solution to it

d) A paper wet with lead (II) acetate turns black, when it is exposed to hydrogen chloride gas.

e) Violet vapors are evolved, when concentrated sulphuric acid reacts with potassium iodide with heating.

B) Illustrate by balanced symbolic equations, how you can differentiate between each pair of the following salts:

a) Sodium nitrite and sodium nitrate.

b) Sodium chloride and aluminum chloride.

C) Mention one use for each of the following reagent with illustrating your answers with symbolic equations:

a) Ammonium hydroxide.   b) Barium chloride.

c) Silver nitrate.   d) Acidified potassium permanganate.

Question (4)

A) Mention the acidic radical of following salts:

1) On adding dilute hydrochloric acid to the solid salt, a colourless gas is evolved which turns reddish brown at the mouth of the tube.

2) On adding dilute hydrochloric acid to the salt a rotten egg, smell gas evolves which turns a paper wet with lead acetate to black.

3) On adding barium chloride solution to the salt solution, a white precipitate is formed, which is soluble in dilute acids.

4) On adding hot concentrated sulphuric acid to the solid salt an orange gas evolves that turns the colour of a starch to yellow.

5) On adding hot concentrated sulphuric acid to the solid salt, a reddish brown vapour appears, which is increased in the

B) Write the name of the gas that is characterized by:

1- Turns a paper wet with acidified potassium dichromate to green.

2- Turns a paper wet with lead acetate to black.

3- Gives white clouds with a glass rod wet with ammonia solution.

4- Gives with a paper wetted with starch solution yellow colour.

5- Turns a paper wetted with starch solution to a blue colour

C) Show by symbolic chemical equations each of the following:

1) Addition of silver nitrate solution to sodium chloride solution.

2) Addition of lead acetate solution to sodium sulphate solution.

3) Addition of barium chloride solution to sodium phosphate solution.

Question (5)

A) Mention the basic radical for the following salts:

1) A cation turns Bunzen flame to a golden yellow colour.

2) On adding caustic soda solution to a salt solution, a white gelatinous precipitate is formed which is soluble in excess of caustic soda solution.

3) On adding ammonium carbonate solution to salt solution, a white precipitate is formed which is soluble in dilute acids.

B) Show by symbolic chemical equations each of the following:

1) Reaction of chlorine gas with hot iron followed by addition of caustic soda solution to the reaction product.

2) Addition of concentrated sulphuric acid to sodium iodide then passing the resultant vapours on a paper wet with starch.

3) Addition of dilute hydrochloric acid to sodium carbonate salt and then passing the resultant gas over a solution of calcium hydroxide for a short time then for a long period.

C) How can you use:

1) Caustic soda to differentiate between iron (II) sulphate and aluminum sulphate.

2) Caustic soda solution to differentiate between iron (III) sulphate and copper sulphate.

3) Magnesium sulphate solution to differentiate between sodium carbonate and sodium bicarbonate.

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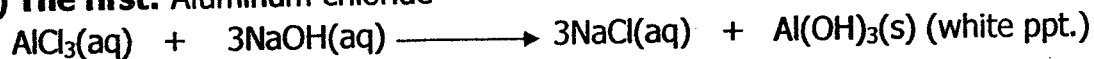Examinations of General Secondary Certificate

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Answer of question (1)

A) a) sulphate.　　　**b)** sulphide.　　　**c)** iron (III).　　　**d)** thiosulphate.

B) The first: Aluminum chloride

$$AlCl_3(aq) + 3NaOH(aq) \longrightarrow 3NaCl(aq) + Al(OH)_3(s) \text{ (white ppt.)}$$

The second: iron (II) chloride

$$FeCl_3(aq) + 3NaOH(aq) \longrightarrow 3NaCl(aq) + Fe(OH)_3(s) \text{ (reddish brown ppt.)}$$

The third: iron (III) chloride

$$FeCl_2(aq) + 2NH_4OH(aq) \longrightarrow 2NH_4Cl(aq) + Fe(OH)_2(s) \downarrow \text{ (green ppt)}$$
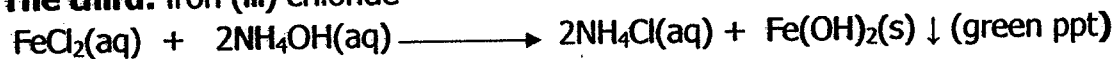
C) a)

Experiment	Sodium sulphite	Sodium sulphate
By adding hydrochloric acid (HCl) acid to each of them.	SO_2 evolves which turns a paper wet with potassium dichromate ($K_2Cr_2O_7$) from orange to green.	No effect

$$Na_2SO_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(\ell) + SO_2(g)$$
$$K_2Cr_2O_7(aq) + 3SO_2(g) + H_2SO_4(aq) \longrightarrow K_2SO_4(aq) + Cr_2(SO_4)_3(aq) + H_2O(\ell)$$
$$Na_2SO_4(aq) + 2HCl(aq) \longrightarrow \text{no effect}$$

b)

Experiment	Iron II chloride	Iron III chloride
By adding NH_4OH solution to the solution of each of them.	A green ppt. of iron (II) hydroxide is formed.	A reddish brown ppt. of iron (III) hydroxide is formed.

$$FeCl_2(aq) + 2NH_4OH(aq) \longrightarrow 2NH_4Cl(aq) + Fe(OH)_2(s) \downarrow \text{ (green ppt.)}$$
$$FeCl_3(aq) + 3NH_4OH(aq) \longrightarrow 3NH_4Cl(aq) + 2Fe(OH)_3(s) \downarrow \text{ (reddish brown ppt.)}$$

Answer of question (2)

A) (1) with (d)　　　(2) with (c)　　　(3) with (b)　　　(4) with (1)

B) a) Iron (II) ion. (Fe^{2+}).　　　**b)** Bicarbonate (HCO_3^-).　　　**c)** Iodide (I^-)

C) The first: the acidic radical is sulphite (SO_3^{2-})

The equation:
$$Na_2SO_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(\ell) + SO_2(g)$$
$$K_2Cr_2O_7(aq) + 3SO_2(g) + H_2SO_4(aq) \longrightarrow K_2SO_4(aq) + Cr_2(SO_4)_3(aq) + H_2O(\ell)$$

The second: the acidic radical is nitrite (NO_2^-)

The equation:
$$NaNO_2(S) + HCl(aq) \longrightarrow NaCl(aq) + HNO_2(aq)$$
$$3HNO_2(aq) \xrightarrow{\Delta} HNO_3(aq) + H_2O(\ell) + 2NO(g)$$
$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$
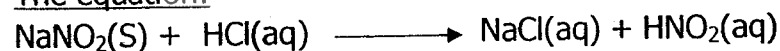
The third: the acidic radical is thiosulphate ($S_2O_3^{2-}$)

The equation:
$$Na_2S_2O_3(s) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(\ell) + SO_2(g)\uparrow + S(s)\downarrow$$
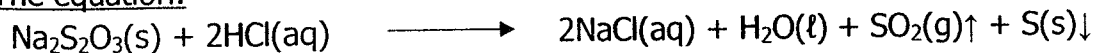
Answer of question (3)

A) a) This is because aluminum hydroxide is formed, which dissolves in excess of NaOH due to formation of sodium aluminate. ($NaAlO_2$)

$$Al_2(SO_4)_3(aq) + 6NaOH(aq) \longrightarrow 3Na_2SO_4(aq) + 2Al(OH)_3(s)\downarrow$$
$$Al(OH)_3(s) + NaOH(aq) \longrightarrow NaAlO_2(aq) + 2H_2O(\ell)$$
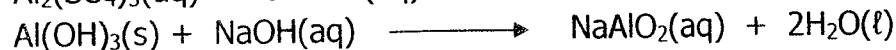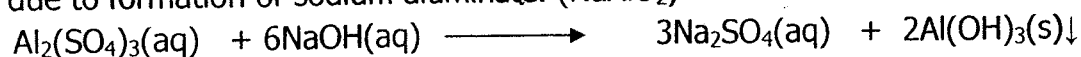
b) Because it reacts with each of them and carbon dioxide is formed which turns lime water milky, as follows:

$$Na_2CO_3(S) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(\ell) + CO_2(g)\uparrow$$

$$NaHCO_3(s) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(\ell) + CO_2(g)\uparrow$$

c) This is because potassium permanganate solution is reduced to colorless compounds.[K_2SO_4 and $MnSO_4$]

$$5NaNO_2 + 2KMnO_4 + 3H_2SO_4 \longrightarrow 5NaNO_3 + K_2SO_4 + 2MnSO_4 + 3H_2O$$

d) This is due to formation of black lead sulphide (PbS).

$$Na_2S(s) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2S(g)$$

$$(CH_3COO)_2Pb(aq) + H_2S(g) \longrightarrow 2CH_3COOH(aq) + PbS(s)\downarrow \text{ [black]}$$

e) This is due to formation hydrogen iodide which reacts with conc. H_2SO_4 violet vapours of iodine, as follows:
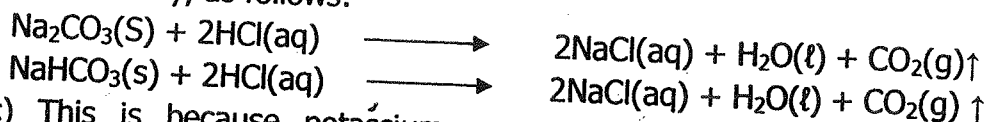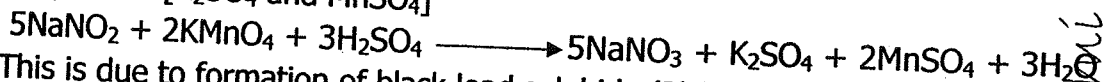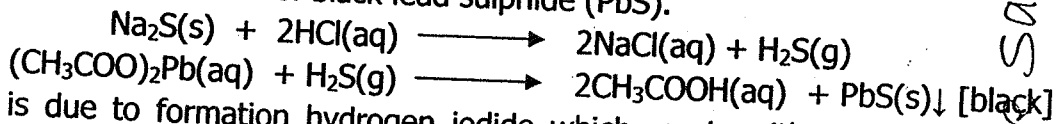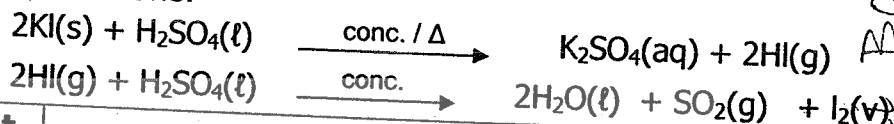
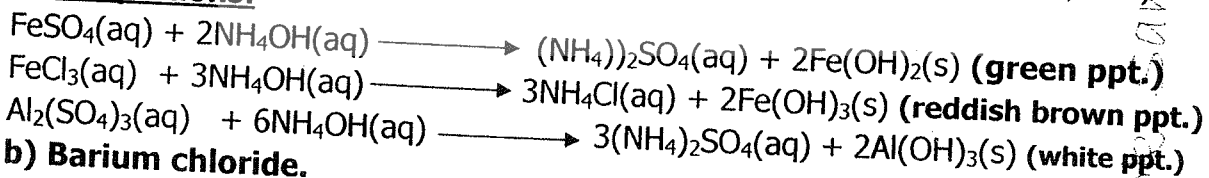$$2KI(s) + H_2SO_4(\ell) \xrightarrow{\text{conc. } / \Delta} K_2SO_4(aq) + 2HI(g)$$

$$2HI(g) + H_2SO_4(\ell) \xrightarrow{\text{conc.}} 2H_2O(\ell) + SO_2(g) + I_2(v)$$

B) a)

Experiment	Sodium nitrite	Sodium nitrate
By adding HCl to each of them.	A colorless gas (NO) evolves turns reddish brown at the mouth of the tube.	No effect
$NaNO_2(s) + HCl(aq) \longrightarrow NaCl(aq) + HNO_2(aq)$ $3HNO_2(aq) \xrightarrow{\Delta} HNO_3(aq) + H_2O(\ell) + 2NO(g)\downarrow$ (colourless gas) $2NO(g) + O_2(g) \longrightarrow 2NO_2(g)\downarrow$ (reddish brown gas) $NaNO_3(s) + HCl(aq) \longrightarrow$ no effect		

b)

Experiment	Aluminum chloride	Sodium chloride
By adding NaOH solution to the solution of each of them	A white ppt. if formed dissolves in excess of NaOH.	No effect
$AlCl_3(aq) + 3NaOH(aq) \longrightarrow 3NaCl(aq) + Al(OH)_3(s)$ (white ppt.) $Al(OH)_3(s) + NaOH(aq) \longrightarrow NaAlO_2(aq) + 2H_2O(\ell)$ (sodium meta aluminate) $NaCl(aq) + 3NaOH(aq) \longrightarrow$ no effect		

C) a) Ammonium hydroxide.

It is used as a reagent for cations of the third analytical group. (Fe^{2+}, Fe^{3+}, Al^{3+}).

The equations:

$$FeSO_4(aq) + 2NH_4OH(aq) \longrightarrow (NH_4)_2SO_4(aq) + 2Fe(OH)_2(s) \text{ (green ppt.)}$$

$$FeCl_3(aq) + 3NH_4OH(aq) \longrightarrow 3NH_4Cl(aq) + 2Fe(OH)_3(s) \text{ (reddish brown ppt.)}$$

$$Al_2(SO_4)_3(aq) + 6NH_4OH(aq) \longrightarrow 3(NH_4)_2SO_4(aq) + 2Al(OH)_3(s) \text{ (white ppt.)}$$

b) Barium chloride.

It is used as a reagent for anions of the third analytical group. (SO_4^{2-}, PO_4^{3-}).

The equations:

$$Na_2SO_4(aq) + BaCl_2(aq) \longrightarrow 2NaCl(aq) + BaSO_4(s)\downarrow$$

(White ppt. does not dissolve in dilute acids)

$$2Na_3PO_4(aq) + 3BaCl_2(aq) \longrightarrow 6NaCl(aq) + Ba_3(PO_4)_2(s)\downarrow$$

(White ppt. dissolves in dilute acids)
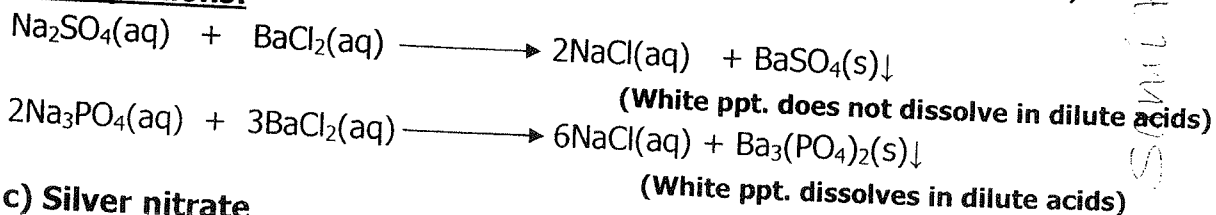
c) Silver nitrate

It is used as a reagent for anions of the second analytical group. (Cl^-, Br^-, I^-).

The equations:

$$NaCl(aq) + AgNO_3(aq) \longrightarrow NaNO_3(aq) + AgCl(s)\downarrow \text{ (white ppt.)}$$
$$NaBr(aq) + AgNO_3(aq) \longrightarrow NaNO_3(aq) + AgBr(s)\downarrow \text{ (white yellow ppt.)}$$
$$NaI(aq) + AgNO_3(aq) \longrightarrow NaNO_3(aq) + AgI(s)\downarrow \text{ (yellow ppt.)}$$

d) Acidified potassium permanganate.

It is used as a reagent for anions of nitrite salts.

The equations:

$$5NaNO_2(s) + 2KMnO_4(aq) + 3H_2SO_4(aq) \longrightarrow NaNO_3(aq) + K_2SO_4(aq) + 2MnSO(aq)_4 + 3H_2O(\ell)$$

The violet colour of $KMnO_4(aq)$ is removed.

Answer of question (4)

A) 1- nitrate.   2- sulphide.   3- sulphate
     4- bromide.   5- nitrate.

B) 1) sulphur dioxide (SO_2)   2) hydrogen sulphide (H_2S)   3) hydrogen chloride (HCl)
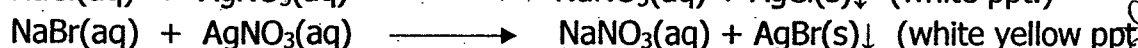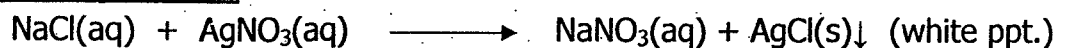   4) bromine vapours (Br_2)   5) iodine vapours (I_2)

C) 1- $NaCl(aq) + AgNO_3(aq) \longrightarrow NaNO_3(aq) + AgCl(s)\downarrow$ (white ppt.)

2- $Na_2SO_4(aq) + (CH_3COO)Pb(aq) \longrightarrow 2CH_3COONa(aq) + PbSO_4(s)\downarrow$ **(white ppt.)**

3- $2Na_3PO_4(aq) + 3BaCl_2(aq) \longrightarrow 6NaCl(aq) + Ba_3(PO_4)_2(s)\downarrow$ **(white ppt.)**

Answer of question (5)

A) 1- sodium   2- aluminum   3- calcium

B) 1- $2Fe(s) + 3Cl_2(g) \xrightarrow{\Delta} 2FeCl_3(s)$

$FeCl_3(s) + 3NaOH(aq) \longrightarrow 3NaCl(aq) + Fe(OH)_3(s)\downarrow$ (reddish brown ppt.)

2- $2NaI(s) + H_2SO_4(\ell) \xrightarrow{conc. / \Delta} Na_2SO_4(aq) + 2HI(g)$

HI gives a blue color with a paper wet with starch solution.

3- $Na_2CO_3(s) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(\ell) + CO_2(g)$

$CO_2(g) + Ca(OH)_2(aq) \xrightarrow{Short\ time} CaCO_3(s)\downarrow + H_2O(\ell)$

$CaCO_3(s)\downarrow + H_2O(\ell) + CO_2(g) \xrightarrow{Long\ time} Ca(HCO_3)(aq)$ [soluble]

C)1) Experiment	Aluminum sulphate	Iron II sulphate
By adding NaOH solution to the solution of each of them	A white ppt. is formed which dissolves in excess of NaOH	A white green ppt. is formed

2) Experiment	Copper II sulphate	Iron III sulphate
By adding NaOH solution to the solution of each of them	A blue ppt. is formed	A reddish brown ppt. is formed

3) Experiment	Sodium carbonate	Sodium bicarbonate
By adding magnesium sulphate solution to the solution of each them.	A white ppt. is formed on cold	A white ppt. is formed after heating

Answer four questions only of the following:

Question (1)

A) Choose the correct answer:

1. The colour of methyl orange in the acidic medium is ....
   a) red   b) blue   c) yellow   d) orange

2. The colour of phenolphthalein in the basic medium is ....
   a) red   b) blue   c) yellow   d) orange

3. The colour of bromo thymol blue in the acidic medium is ....
   a) red   b) blue   c) yellow   d) orange

4. The colour of litmus solution in the acidic medium is ....
   a) red   b) blue   c) yellow   d) orange

5. Phenolphthalein is .... in the acidic medium.
   a) red   b) blue   c) yellow   d) colourless

6. The indicator which has a yellow colour in the acidic medium is ....
   a) Methyl orange.   b) phenolphthalein.   c) litmus.   d) bromo thymol blue.

B) Compare between: Quantitative analysis and Qualitative analysis.

C) Mention one use for each of the following:

   a. Methyl orange
   b. Ash less filter paper
   c. Burette

D) A 20 ml of calcium hydroxide solution $Ca(OH)_2$ was titrated with 0.5 molar hydrochloric acid. At the end of reaction, 25 ml of the acid was consumed. Calculate the concentration of calcium hydroxide (mole/liter)

Question (2)

A) Write the suitable scientific expression for:

1. Compounds that their colours change according to the pH of the medium.
2. A chemical analysis is used to identify the constituents of the substance.
3. A chemical analysis is used to determine the concentration of the constituents of the compound.
4. A solution its concentration is known.
5. The point at which the complete reaction takes place.
6. The indicator which is colourless in the acidic medium.
7. The reactions that are used to determine the substances which can give sparingly soluble compounds.
8. The indicator that gives yellow colour in the acidic medium and gives blue colour in the basic medium (in light of your study)

B) What is the mathematical equation which illustrates the relation between volumes and concentrations of both acid and alkali at the end point of titration process?

C) Calculate the volume of 0.1 molar hydrochloric acid solution required for titration of 20 ml of 0.5 molar sodium carbonate solution till complete reaction.

D) Find out the mass of sodium hydroxide present in 25 ml solution which consumes, by titration, 15 ml of 0.1 molar hydrochloric acid solutions. [Na=23, O=16, H=1]

Question (3)

A) What is the scientific explanation for:

1. Phenolphthalein indicator is not used to detect acids.
2. The basic solution cannot be used to differentiate between litmus indicator and bromothymol blue indicator.
3. Ashless filter papers is used in the chemical analysis by precipitation method.

B) The colour is considered as one of the physical properties which is used to identify substances. Mention the specific colour for each of the following:

a. Methyl orange in an alkaline medium.
b. Bromo thymol blue in the acidic medium.
c. Phenolphthalein in an alkaline medium.

C) Rewrite the following statements after correcting the underlined words:

1. When bromo thymol blue is added to hydrochloric acid gives **blue** colour.
2. When methyl orange is added to sodium hydroxide gives **red** colour.

D) A 0.1 gram of a mixture of solid substance containing sodium hydroxide and sodium chloride was titrated with 0.1 molar hydrochloric acid. The complete reaction (end point) takes place by the consumption of 10 ml of the acid. Calculate the% sodium hydroxide in the mixture.

Question (4)

A) What is meant by:

1. Titration.   2. The standard solution.   3. Ash less filter paper.

B) How can you differentiate practically between:

1. Litmus solution and phenolphthalein solution.
2. Methyl orange and bromo thymol blue.

C) What is meant by Indicators? (Give an example).

D) 2.6903 grams of hydrated barium chloride salt ($BaCl_2.XH_2O$) was strongly heated until a constant mass of 2.2923 grams. Calculate the % of water of crystallization of the hydrated barium chloride. Find out the number of water molecules of crystallization and write the molecular formula of the salt.

(O=16, H=1, Cl=35.5, Ba=137)

Question (5)

A) A two gram portion of impure sodium chloride was dissolved in water. Excess of silver nitrate was added to precipitate 4.628 grams of silver chloride .Calculate the % of chlorine in the sample.   [Na = 23, Cl = 35.5, Ag =108]

B) What is the role of each of the following?

1. Analytical chemistry Medical field.
2. Analytical chemistry in agriculture.
3. Indicators in titration process.

C) What is the scientific base for precipitation method in analytical chemistry? Illustrate its steps.

D) Sodium sulphate solution was added to a solution of barium chloride till complete precipitation of barium sulphate. The mass of the isolated precipitate after filtration and drying was found to be 2 grams. Calculate the mass of barium chloride in the solution.   (O = 16, S = 32, Cl = 35.5, Ba = 137)

Answer of question (1)

A) 1	2	3	4	5	6
a	a	c	a	d	d

B) Quantitative analysis	Qualitative analysis
It is a process of determination of the concentration or quantity of the constituents of the sample.	It is a process of identification of the constituents of the substance.

C) a. **Methyl orange** is used to identify if the solution is acidic or alkaline or neutral.

b. **Ash less filter paper** is used to

c. **Burette** is used to determine the volume of liquid accurately during titration.

D)
$$2HCl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O$$

Hydrochloric acid   Calcium hydroxide
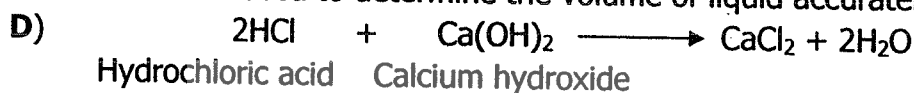
$$\frac{M_a \times V_a}{n_a} = \frac{M_b \times V_b}{n_b}$$

$$\frac{0.5 \times 25}{2} = \frac{M_b \times 20}{1}$$

$$M_b \times 40 = 0.5 \times 25$$

Concentration of calcium hydroxide (M_b) = $\dfrac{0.5 \times 25}{40}$ = 0.3125 moles/liter

Answer of question (2)

A) 1. Indicators

2. Qualitative analysis

3. Quantitative analysis

4. Standard solution

5. Neutralization point (end point)

6. Phenolphthalein

7. Precipitation reaction

8. Bromo thymol blue

B)

$$\frac{M_a \times V_a}{n_a} = \frac{M_b \times V_b}{n_b}$$

C)
$$2HCl + Na_2CO_3 \longrightarrow 2NaCl + CO_2 + H_2O$$

Acid (**HCl**)   Base (**Na_2CO_3**)

M_1 = 0.1 molar M_2 = 0.5 molar

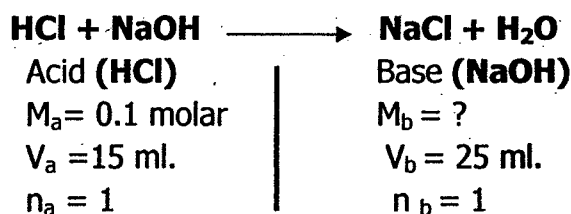V_1 = ? V_2 = 20 ml.

M_a = 2 M_b = 1

$$\frac{M_a \times V_1}{n_a} = \frac{M_b \times V_b}{n_b}$$

$$\frac{0.1 \times V_a}{2} = \frac{0.5 \times 20}{1}$$

$$0.1 \times V_a = 2 \times 0.5 \times 20$$

$$V_a = \frac{2 \times 0.5 \times 20}{0.1} = 200 \text{ ml.}$$

D)

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

Acid **(HCl)**	Base **(NaOH)**
M_a = 0.1 molar	M_b = ?
V_a = 15 ml.	V_b = 25 ml.
n_a = 1	n_b = 1

$$\frac{M_a \times V_a}{n_a} = \frac{M_b \times V_b}{n_b}$$

$$\frac{0.1 \times 15}{1} = \frac{M_b \times 25}{1}$$

$$0.1 \times 15 = M_b \times 25$$

$$M_b = \frac{0.1 \times 15}{25} = 0.06 \text{ molar}$$

Mass of 1 mole of NaOH = 23 + 16 + 1 = 40 gm.

Number of moles = volume in liter x concentration

$$= \frac{25}{1000} \times 0.06 = 0.0015 \text{ mole.}$$

The mass of NaOH = Number of moles x mass of one mole

$$= 0.0015 \times 40 = 0.06 \text{ gm.}$$

Answer of question (3)

A) 1. Because it is colourless in acidic medium.

2. Because the colour of both is blue in the alkaline medium.

3. Because this type of filter papers upon ignition leaves no ash.

B) a. The colour of Methyl orange in an alkaline medium is **red.**

b. The colour of Bromo thymol blue in the acidic medium is **blue.**

c. The colour of Phenolphthalein in an alkaline medium is **red.**

C) 1. When bromo thymol blue is added to hydrochloric acid gives **yellow** colour.

2. When methyl orange is added to sodium hydroxide gives **yellow** colour.

D)

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

Number of moles of hydrochloric acid used = $\dfrac{\text{Volume x concentration}}{1000}$

Number of moles of hydrochloric acid used = $\dfrac{10 \times .1}{1000} = 0.001$ mole

1 mole of sodium hydroxide reacts with 1 mole of hydrochloric acid

Therefore number of moles of sodium hydroxide = 0. 001 mole/liter

1 mole of sodium hydroxide (NaOH) = 23 +16 + 1= 40 grams

The mass of sodium hydroxide in the mixture = 40 x 0.001 = 0.04 grams

% Sodium hydroxide in the mixture = $\dfrac{0.04 \times 100}{0.1} = 40\ \%$

Answer of question (4)

A) 1. Titration: is a process in which a certain volume of a solution of known concentration is added to another solution of unknown concentration till the complete reaction between the two solutions.

2. The standard solution: is a solution its concentration is known.

3. Ash less filter paper: is a type of papers upon ignition leaves no ash.

B) 1. Experiment	Litmus solution	Phenolphthalein solution
By adding HCl acid to each of them.	Red	Colourless
By adding NaOH to each of them.	Blue	Red

2. Experiment	Methyl orange	Bromo thymol blue
By adding HCl acid to each of them.	Red	Yellow
By adding NaOH to each of them.	Yellow	Blue

C) **Indicators:** are compounds that their colours change according to the pH of the medium.

Examples of indicators:

- Methyl orange
- Litmus
- Phenolphthalein
- Bromo thymol blue

D) Mass of water of crystallization = 2.6903 - 2.2923 = 0.398 grams

% Water of crystallization = $\dfrac{0.398}{2.6903} \times 100 = 14.79\%$

The molecular mass of $BaCl_2$ = 137 + (2 × 35.5) = 208 grams

2.2923 gm. of anhydrous $BaCl_2$ — 0.398 gm. of water
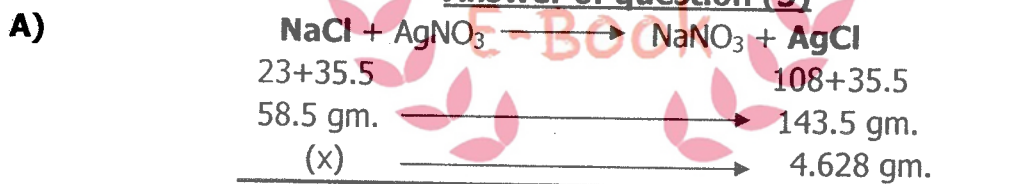
208 gm. of anhydrous $BaCl_2$ — (X) gm. of water

(X) Mass of water of crystallization = $\dfrac{208 \times 0.398}{2.2923} = 36.114$ gm.

Molecular mass of water = (1 × 2) + (16 × 1) = 18 grams

The number of molecules of water of crystallization = $\dfrac{36.114}{18} = 2.006$ molecules

The molecular formula of hydrated barium chloride is $BaCl_2 . 2H_2O$.

Answer of question (5)

A)

$$NaCl + AgNO_3 \longrightarrow NaNO_3 + AgCl$$

23 + 35.5   108 + 35.5

58.5 gm. ⟶ 143.5 gm.

(x) ⟶ 4.628 gm.

The mass of NaCl (x) = $\dfrac{58.5 \times 4.628}{143.5} = 1.887$ gm.

$$NaCl \longrightarrow Cl$$

58.5 gm. ⟶ 35.5 gm.

1.887 gm. ⟶ (x)
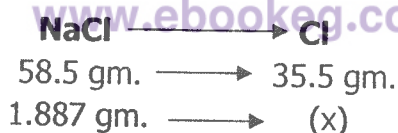
The mass of chlorine = $\dfrac{1.887 \times 35.5}{58.5} = 1.145$ gm.

% of chlorine in the sample = $\dfrac{1.145 \times 100}{2} = 57.25\%$

B) **1- The role of Analytical chemistry in Medical field**

1. Measurement of the active ingredients (components) in drugs.
2. Analysis of sugar in blood and urine.

2- The role of Analytical chemistry in agriculture:

Knowing the constituents of the soil and rocks to decide whether the soil is suitable or not for cultivation.

3- The role of Indicators in titration process helps us to know the end point during neutralization of an acid with an alkali.

C) The scientific base for precipitation method:

Precipitation of the analyte in the form of pure sparingly soluble compound with constant and known chemical structure.

Steps:

1. The precipitate is isolated from the solution by filtration on an ash less filter paper (a type of filter papers upon ignition leaves no ash).

2. The filter paper with the precipitate is transferred to an ignition crucible and completely ignited until volatilization of the constituents of the filter paper. The mass of the precipitate remains after ignition.

3. The precipitate is weighed and used for determining the mass of the analyte.

D) Mass of 1 mole of $BaCl_2$ = 137 + (2 × 35.5) = 208 g

Mass of 1 mole of $BaSO_4$ = 137 + 32 + (4 × 16) = 233 g

$$BaCl_2 + Na_2SO_4 \longrightarrow BaSO_4 + 2NaCl$$

208 grams $\longrightarrow$ 233 grams

(X) grams $\longrightarrow$ 2 grams
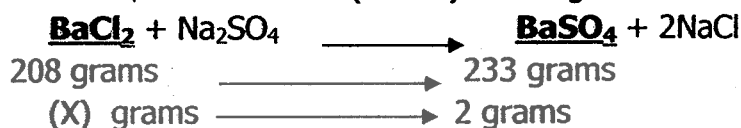
$$(X) \text{ Mass of barium chloride}) = \frac{208 \times 2}{233} = 1.785 \text{ grams.}$$
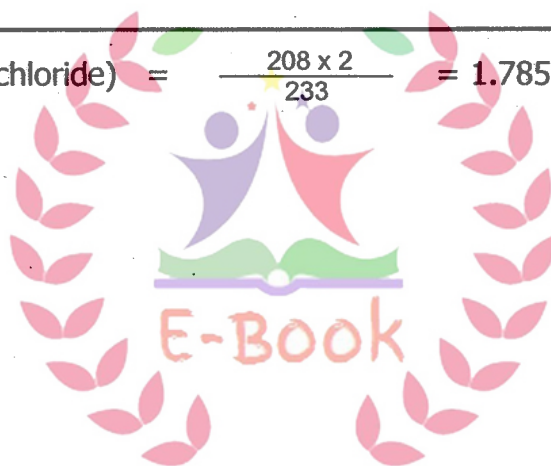
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In

Biology

Chemistry

Physics

Answer four questions only of the following:

Question (1)

A) Choose the correct answer:

1. In the following equilibrium reaction:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) , \Delta H = -92Kj$$

The concentration of ammonia (NH_3) can be increased by one of the following methods:

a- Decreasing the amount of nitrogen.   b- Increasing the temperature.

c- Decreasing the amount of hydrogen.   d- Increasing pressure.

2. The relation between the rate of chemical reaction and the concentration is related to ....

a- Heisenberg.   b- Le chattelier.   c- Waage and Guldberg.   d- Schrodinger.

3. The role of the catalyst in the reversible reactions is to...........

a- reach the equilibrium state quickly.

b- increase the rate of the backward reaction only.

c- decrease the rate of the backward reaction only.

d- increase the rate of the forward reaction only.

4. All the following factors affect a system already in a state of equilibrium except.......

a- concentration.   b- temperature.   c- catalyst.   d- pressure.

5. Addition of sodium chloride solution to silver nitrate solution is a ...reaction.

a- complete (irreversible).   b- instantaneous

c- reversible   d- answers (a) & (b) are right.

6. The reaction of hydrochloric acid with magnesium is a complete (irreversible) reaction as ....

a- it occurs at high temperature.   b- it occurs under high pressure.

c- hydrogen gas is evolved.

d- there is an equilibrium between the reactants and the products.

B) Show by balanced chemical equations what happens in each of the following cases:

  a) Adding magnesium ribbon in dilute hydrochloric acid.

  b) Cooling a glass flask containing nitrogen dioxide gas.

  c) Addition of iron (III) chloride solution to ammonium thiocyanate solution.

C) Compare between:

  The complete reaction and incomplete reaction show your answer by equations.

D) Calculate the equilibrium constant Kp for the reaction:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g), \Delta H = -92 KJ$$

The pressures of the gases are: 2.3 atmosphere for N_2, 7.1 atmosphere for H_2 and 0.6 atmosphere for NH_3. **Comment** on the value of K_P and how could the product of the reaction be increased? **And why?**

Question (2)

A) Write the suitable scientific expression for:

  1. The change of concentration of the reactants with time unit.

  2. At constant temperature, the rate of a chemical reaction is directly proportional to the product of multiplication of the reactant concentrations, each is raised to the

power of the number of molecules or ions in the balanced chemical equation.

3. The minimum amount of energy that must be gained by a molecule to react al collision.

4. Molecules which have kinetic energy that equals or exceeds the activation energy.

5. A dynamic system takes place when the rate of forward reaction equals the rate of backward reaction. The concentrations of the reactants and products are not changed.

6. Protein molecules produced in living cells that act as catalysts for many biological and industrial processes.

7. A substance which change the rate of the chemical reaction without itself being changed.

B) Choose from coulomb (B) the factors which increase from the products in the reactants which in the coulomb (A):

(A)	(B)
The reactants	**The factors which increase the product of reaction**
(1) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$	(a) increasing the pressure.
(2) $2NO_2 \rightleftharpoons N_2O_4$	(b) decreasing the concentration of the reactants.
(3) $N_2 + O_2 + Heat \rightleftharpoons 2NO$	(c) raising the temperature.
(4) $H_2 + Cl_2 \rightleftharpoons 2HCl + Heat$	(d) reducing the temperature.
	(e) decreasing the pressure.

C) Explain the role of each of the following:

1. Catalysts in industry.
2. Le Chatelier in explaining the scientific bases.
3. Catalysts in the chemical reactions.

D) The following reaction has two equilibrium constant values at two different temperatures

$$H_{2\,(g)} + I_{2\,(g)} \rightleftharpoons 2HI_{(g)}$$

K_c at 850 °C = 67 and at 448 °C = 50
Is this reaction exothermic or endothermic? Why?

Question (3)

(A) What is the scientific explanation for:

1. The rate of a chemical reaction increases by increasing the temperature.
2. Thermal decomposition of copper (II) nitrate is a complete reaction.
3. The catalyst does not affect the position of equilibrium in the reversible reactions.
4. The reaction of iron with dilute hydrochloric acid is a complete reaction.
5. The rate of reaction of hydrochloric acid with iron filings is faster than that with an equal mass of iron block.

B) Explain the following:

Effect of pressure and temperature on the increase of the rate of the formation of ammonia according to the equation:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3, \Delta H = -92\ KJ$$

C) From your study to the chemistry explain how the following scientists contributed to the development of the chemistry:

1. Guldberg and Waage.   2. Le Chatelier.

D) The following reaction has reached the equilibrium state:

$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g) , \Delta H = 41.1 \text{ KJ}$$

What is the action of each of the following changes on the concentration of hydrogen gas:
1. Adding excess of carbon dioxide gas.
2. Raising the temperature
3. Adding a catalyst.
4. Decreasing the volume of the container.

Question (4)

A) **What is meant by:**
1. The saturated water vapour pressure.
2. Catalysts.
3. The rate of chemical reaction
4. Activation energy
5. Le chatelier's principle
6. Equilibrium state.

B) In the balanced reaction:

$$CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

What happens to the equilibrium of this reaction in the following cases?
1) Adding excess of water.
2) Adding drops of cone sulphuric acid.

C) If the equilibrium constant for the following reaction is 15.75

$$Cl_2 + PCl_3 \rightleftharpoons PCl_5$$

And the concentrations of chlorine and phosphorous trichloride were 0.3 and 0.84 mole/ liter respectively. Calculate the concentration of phosphorous pent chloride.

D) State the law of mass action referring to the equation:

$$FeCl_3 + 3NH_4SCN \rightleftharpoons Fe(SCN)_3 + 3NH_4Cl$$
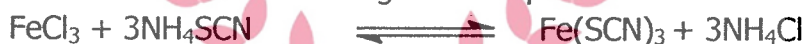
And write the equilibrium constant of the reaction, what is the effect of adding an excess oh ammonium thiocyanate to the above reaction

Question (5)

A) **What are** the factors that affect the rate of chemical reactions?

B) **Consider** the reaction at equilibrium:

$$CH_3COOH + H_2O \underset{r_2}{\overset{r_1}{\rightleftharpoons}} CH_3COO^- + H_3O^+$$
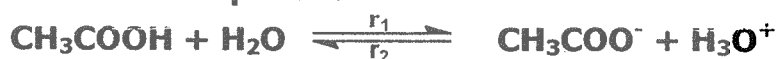
Explain the effect of each of the following changes on the concentration of acetate ion:
1) Adding drops of hydrochloric acid.
2) Adding drops of sodium hydroxide solution.

C) **Explain a practical experiment** showing the effect of temperature on a chemical reaction already in a state of equilibrium.

D) **Calculate the equilibrium** constant for the reaction:

$$I_2 + H_2 \rightleftharpoons 2HI$$

Provided that concentrations of iodine, hydrogen and hydrogen iodide at equilibrium are 0.1105, 0.1105 and 0.7815 mole/liter respectively.

Answer of question (1)

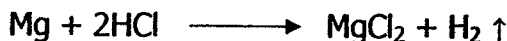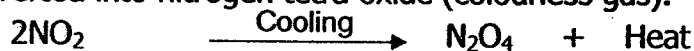| A)	1	2	3	4	5	6
	d	c	a	c	d	c

B) a- Hydrogen gas evolves and the reaction moves towards the forward direction.
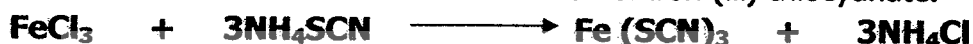
$$Mg + 2HCl \longrightarrow MgCl_2 + H_2 \uparrow$$

b- The reaction moves towards the forward direction and nitrogen dioxide (reddish brown) is converted into nitrogen tetra oxide (colourless gas).

$$2NO_2 \xrightarrow{\text{Cooling}} N_2O_4 + \text{Heat}$$
(Reddish brown)   **(Colourless)**

c- The reaction moves towards the forward direction and the colour of the reaction mixture becomes blood red due to the formation of iron (III) thiocyanate.

$$FeCl_3 + 3NH_4SCN \longrightarrow Fe(SCN)_3 + 3NH_4Cl$$
     Ammonium thiocyanate   **Iron (III) thiocyanate**
     (Colourless)   **(Red)**

C) Complete (irreversible) reactions	Incomplete (reversible) reactions
1.The reactions which proceed in one direction (forward).	1. The reactions which proceed in both directions forward and backward.
2. One of the products escapes from the system as evolving of a gas or forming a precipitate.	2.Both the reactants and products are always found in the reaction medium
Example: $NaCl + AgNO_3 \longrightarrow NaNO_3 + AgCl \downarrow$ $Mg + 2HCl \longrightarrow MgCl_2 + H_2 \uparrow$	**Example:** $CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$ $2NO_2 \rightleftharpoons N_2O_4 , \Delta H = -ve$

D) $K_P = \dfrac{p^2[NH_3]}{P[N_2] \times P^3[H_2]} = \dfrac{(0.6)^2}{2.3 \times (7.1)^3} = 4.373 \times 10^{-4}$

- The small value of equilibrium constant ($K_p < 1$) means that the concentration of the products are less than the concentration of the reactants which reveal that the reaction is not proceed well towards the formation of the products and that the reversible reaction has an effective role.

- The product of the reaction can be increased by:

1- Increasing the pressure.

2- Increasing the concentration of the reactants.

Answer of question (2)

A) 1. Rate of chemical reaction.   2. Law of mass action

3. Activation energy   4. Activated molecules

5. Chemical equilibrium   6. Enzymes

7. Catalyst

B) (1) with (e)   (2) with (a)   (3) with (c)   (4) with (d)

C) 1. Catalysts are used in industry to accelerate the slow reactions in industry to save money that are paid for using fuel to raise the temperature of slow reactions in factories, as a result, the price of the final products will be decreased.

2. Le Chatelier formulated a rule named after him. This rule predicts the effect of different factors such as concentration, temperature and pressure on the systems

under equilibrium. This formula states that:

"The changes in any of the conditions of a chemical equilibrium such as concentration, pressure or temperature cause shift of the equilibrium in the direction which will oppose this change"

3. Catalysts cause a change in the rate of chemical reaction without itself being changed.

D) $Ka = \dfrac{[HI]^2}{[H_2] \times (I_2)}$

- Since the value of (Ka) for the reaction increased by raising the temperature, i.e. the concentration of the products of the reaction increased by raising the temperature, therefore the reaction is endothermic.

Answer of question (3)

A) 1. Increasing temperature increases the rate of collisions between molecules and this leads to increases their kinetic energy which is high enough to break the bonds within the molecules so that the chemical reaction can take place.

2. Because oxygen and nitrogen dioxide gases evolve and escape from the medium of the reaction.

$$2Cu(NO_3)_2 \xrightarrow{\Delta} 2CuO + 4NO_2 + O_2$$

3. Because it changes the rate of reaction of both reactants and products and does not affect the equilibrium position.

4. Because hydrogen gas evolves and escapes from the medium of the reaction.

$$Fe + 2HCl \longrightarrow FeCl_2 + H_2 \uparrow$$

5. Because as the surface area exposed to the reaction increases, the rate of reaction increases.

B) $$N_2 + 3H_2 \underset{\text{Heating}}{\overset{\text{Cooling}}{\rightleftharpoons}} 2NH_3, \quad \Delta = -92 \text{ Kj}$$

High pressure   **Low pressure**

- By increasing the pressure, the rate of the formation of ammonia increases because the reaction shifts towards the forward direction to oppose this change. By decreasing the pressure the opposite takes place.
- By increasing the temperature, the rate of the formation of ammonia decreases because the reaction shifts towards the backward direction to oppose this change. By decreasing the temperature the opposite takes place.

C) 1. **Waage and Guldberg:** discovered the law of mass action which controls the relation between velocity of the chemical reaction and concentration of the reactants. This law states that the rate of the chemical reaction is directly proportional to the product of multiplication of the reactant concentrations; each is raised to the power of the number of molecules or ions in the balanced chemical equation

2. **Le Chatelier:** formulated a principle which state that the change in any of the condition of a chemical reaction at equilibrium state such as concentration, temperature or pressure, the reaction will be shifted in the opposite direction of this change.

D) 1. Decreases the concentration of hydrogen.

2. Decreases the concentration of hydrogen.

3. Does not affect the concentration of hydrogen.

4. Does not affect the concentration of hydrogen.

Answer of question (4)

A) 1. **The saturated water vapour pressure:** is the maximum water vapour pressure of water at a certain temperature.

2. **Catalyst:** is the substance that causes a change in the rate of chemical reaction without itself being changed.

3. **The rate of chemical reaction:** is the change in concentration of the reactants or products per unit time.

4. **Activation energy:** is the minimum amount (quantity) of energy that must be gained by a molecule to react at collision

5. **Le chatelier's principle:** "The changes in any of the conditions of a chemical equilibrium such as concentration, pressure or temperature will shift the equilibrium to the opposite direction".

6. **Equilibrium state:** is the state of equilibrium in the reversible reaction at which the rate of forward reaction equals the rate of backward reaction.

B) 1. The reaction moves towards the backward direction to oppose this change.

2. The acid absorbs the water and the reaction moves towards the forward direction to oppose this change.

C) Equilibrium constant $K_c = \dfrac{[PCl_5]}{[Cl_2][PCl_3]}$

$$15.75 = \frac{[PCl_5]}{[0.3][0.84]}$$

$$15.75 = \frac{[PCl_5]}{0.252}$$

The concentration of $PCl_5 = 15.75 \times 0.252 = 3.969$ mole/liter

D) **Law of mass action:** At constant temperature, the rate of a chemical reaction is directly proportional to the product of multiplication of the reactant concentrations; each is raised to the power of the number of molecules or ions in the balanced equation.

$$K_c = \frac{[Fe(SCN)_3]\,[NH_4Cl]^3}{[FeCl_3]\,[NH_4SCN]^3}$$

On adding an excess of ammonium thiocyanate to the reaction the reaction moves towards the forward direction and a blood red colour of iron (III) thiocyanate appears.

Answer of question (5)

A) The factors affecting the rate of chemical reaction are:

1- Nature of the reactants (it includes type of bonding and the surface area)

2- Concentration of the reactants.

3- Reaction temperature.

4- Pressure.

5- Catalysts.

6- Light.

B) 1. Adding drops of HCl leading to increase the concentration of Hydronium ion in the solution as a result of combination between the Hydrogen ion of the acid and

water molecules in the solution, according to Le Chatelier's principle, the reaction shifts in the direction which decreases the concentration of Hydronium ion then the concentration of acetate ion decreases.

2. Adding drops of Sodium hydroxide neutralizes acetic acid, the concentration of the acid decrease, according to Le Chatelier's principle the reaction shifts in the direction which increases the concentration of the acid then the concentration of acetate ion decreases.

C) Experiment	Observation	Result
Bring a flask filled with nitrogen dioxide gas (reddish brown colour) and place it in a cooling mixture.	The intensity of the colour decreases gradually, until the reddish brown colour disappears.	- In an exothermic reaction reached the equilibrium state:
- Remove the flask containing the gas from the cooling mixture and kept at room temperature (25 °C),	- The reddish brown colour starts to reappear gradually.	- The decrease in temperature forces the reaction to proceed in the forward direction.
- Place the flask in hot water.	The intensity of the reddish brown colour increases gradually,	- The increase in temperature forces the reaction to proceed in the backward direction.

Cooling mixture   Room temprature   Hot water

$$2NO_2 \underset{\text{Heating}}{\overset{\text{Cooling}}{\rightleftharpoons}} N_2O_4 + \text{Heat}$$

(Reddish brown)   (Colourless)

D) $K_c = \dfrac{[HI]^2}{[H_2][I_2]} = \dfrac{[0.7815]^2}{[0.1105] \times [0.1105]} = 50.018$

Sami Book
In
Chemistry

Graduated Exams with the model answers

Examinations of General Secondary Certificate

with the model answers

Answer four questions only of the following:

Question (1)

A) Choose the correct answer:

1. The products of hydrolysis of sodium carbonate salt in water are carbonic acid and
....
   - a- hydrogen ions and sodium ions.
   - b- sodium ions and hydroxide ions.
   - c- sodium hydroxide.
   - d- carbonate ions and sodium ion.

2. Blue litmus paper turns red in the hydrolysis of ....salt.
   - a- ammonium acetate.
   - b- ammonium chloride
   - c- sodium carbonate.
   - d- ammonium carbonate

3. One of the following salt solutions turns litmus blue.........
   - a- potassium sulphate.
   - b- ammonium acetate.
   - c- iron (III) nitrate.
   - d- sodium acetate.

4. The ionic product of water equals ....mol/liter.
   - a- 10^{-14}
   - b- 10
   - c- 10^{-4}
   - d- 10^{-9}

5. (0.001) molar solution of hydrochloric acid has a pH value equals ....
   - a- 3
   - b- 1
   - c- zero
   - d- 11

6. The solution of pure acetic acid in water.......
   - a- Contains ions and illuminate a lamp which is connected to two poles dipped in the solution.
   - b- Does not contain ions and does not illuminate the lamp which is connected to two poles dipped in the solution.
   - c- Contains ions that decrease in number on dilution with water.
   - d- Both answers (a) and (c) are correct.

B) Which solution of the following substances is acidic, basic or neutral?

$(NH_4)_2CO_3$, KCl, NH_4NO_3, $FeCl_3$

C) Compare between:

1. Chemical equilibrium and ionic equilibrium.
2. Neutralization and hydrolysis.

D) Calculate the concentration of hydronium ions (H_3O^+) in a 0.2 molar solution of acetic acid at 25°C given that the equilibrium constant of the acid is (1.8×10^{-5}).

Question (2)

A) Write the suitable scientific expression for:

1. The resultant of multiplying the concentration of the hydrogen ion times that of hydroxyl ion produced by water ionization.
2. An expression to express the degree of acidity or alkalinity of aqueous solutions using positive successive numbers.
3. The negative logarithm of hydrogen ion concentration.
4. An ion formed from binding water molecule with a proton produced from ionization on an acid.

B) Give reasons for:

1. Sodium chloride Solution has a neutral effect on litmus.

2. Ammonium acetate solution has a neutral effect on litmus.

3. Hydrochloric acid and sodium hydroxide are not formed on dissolving table salt in water, while acetic acid and ammonium chloride are formed on dissolving ammonium acetate in water.

4. There are no positive hydrogen ions (protons) in the aqueous solution of strong acids.

5. Pure water has neutral effect on litmus.

C) Which of the following solutions is acidic, alkaline and neutral.

a) Solution of a pH 3.5.　　　　b) Solution of a pH 7.

c) Solution of a pH 4.　　　　　d) Solution of a pH 12.

D) Solution contains solid barium sulphate ($BaSO_4$) in the equilibrium state with its ions, as in the following equation:

$$BaSO_4 (s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$$

If the concentration of barium ions, in equilibrium, is 1.04×10^{-5} mole/liter, calculate the value of the solubility product of barium sulphate.

Question (3)

A) What is the scientific explanation for:

1. Sodium carbonate solution has alkaline effect on litmus paper.

2. Ammonium chloride solution has acidic effect on litmus paper.

3. The colour of ammonium chloride solution change into red on adding drops of methyl orange solution to it.

4. The aqueous solution of hydrogen chloride in water conducts electricity more than the aqueous solution of acetic acid.

5. The ionic product of water $K_w = [10^{-7}][10^{-7}] = 10^{-14}$

B) Fill the empty spaces in the following table, given that the ionic product of water is 1×10^{-14} at 25 °C.

$[H^+]$	$[OH^-]$	pH	pOH
1×10^{-11}	-------------	-------------	-------------
-------------	1×10^{-5}	-------------	-------------
-------------	-------------	6	-------------
-------------	-------------	-------------	12

C) What is the name of the scientist who did the following?

Found the relationship between the degree of dissociation (α) and the concentration (C) in mole/liter.

D) Calculate the degree of dissociation in 0.1 molar hydrocyanic acid (HCN) solution at 25°C. Providing that the equilibrium constant of the acid $Ka = 7.2 \times 10^{-10}$

Question (4)

A) What is meant by:

1. Ionic equilibrium.　　2. Ionic product of water (K_w)　　3. Solubility product.

B) Arrange the following compounds according to the pH value of their aqueous solutions: [$NaCl - CH_3COONa - NH_4Cl$]

C) Find the pH values and mention the acidic, alkaline or neutral effect of the following solutions, the H^+ concentration in these solutions are:

a) 10^{-5}　　　　b) 10^{-12}　　　　c) 10^{-7}

D) The degree of solubility of aluminum hydroxide is 10^{-6} mole/liter. Calculate the solubility product of $Al(OH)_3$

Question (5)

A) Correct the underlined word:

1. Sodium carbonate solution has a **neutral** effect on litmus.
2. The ionic product of water is the resultant of multiplying the concentration of the hydrogen ion and **oxygen** ion produced from the ionization of water.
3. Ammonium acetate solution has an **acidic** effect on litmus paper.
4. The solution is **neutral**, when its pH value is less than 7.
5. Ionization is a process in which unionized molecules are changed into **atoms**.

B) Pure water, which is a weak electrolyte, is a poor conductor to electricity, answer the following:

a. Write the equilibrium equation expressing ionization of water.

b. What is the type of equilibrium of water ionization?

C) How you can differentiate between:

1. An ionic compound and a covalent compound.
2. Dilute acetic acid and pure acetic acid.

D) The following equation indicates the ionization of a weak base, ammonium hydroxide (ammonia solution), and its concentration C = 0.1 M.

$$NH_4OH_{(aq)} \rightleftharpoons NH_{3(aq)} + OH^-_{(aq)}$$

If the ionization constant of the base, $K_b = 1.6 \times 10^{-5}$, calculate:

a- The degree of ionization of the base.

b- The hydroxyl ion concentration in the alkaline solution

c- The pOH value of the solution.

d- The pH value of the solution.

Answer of question (1)

A) 1	2	3	4	5	6
b	b	d	a	a	a

B) $(NH_4)_2CO_3$ [neutral solution]   KCl   [neutral solution]

      NH_4NO_3,   [acidic solution] $FeCl_3$ [acidic solution]

C) 1. **Chemical equilibrium**	**Ionic equilibrium**
It is a state of equilibrium in the reversible reaction at which the rate of forward reaction equals the rate of backward reaction.	It is the equilibrium arising between molecules of a weak electrolyte and the ions resulting from it.

2. **Hydrolysis of salt solutions**	**Neutralization**
It is the reaction of the salt with water to form the acid and alkali from which the salt is derived.	It is the reaction of an acid with an alkali to form a salt and water.

(D) $[H_3O^+] = \sqrt{C_a X K_a}$

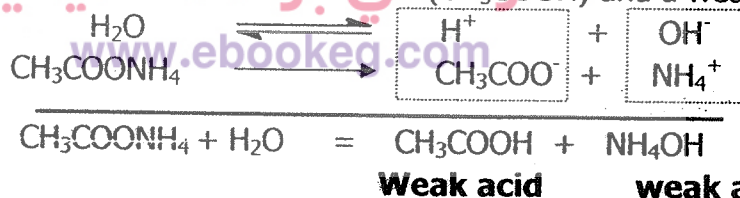 $[H_3O^+] = \sqrt{0.2 \times 1.8 X 10^{-5}}$ = 2.684×10^{-3} molar

Answer of question (2)

A) 1. Ionic product of water.   2. pH value.   3. pH value.   4. Hydronium

B) 1. Because the salt is derived from a strong acid (HCl) and a strong alkali (NaOH).

$$H_2O \rightleftharpoons H^+ + OH^-$$
$$NaCl \longrightarrow Cl^- + Na^+$$
$$NaCl + H_2O = H^+ + Cl^- + Na^+ + OH^-$$

                 Strong acid   **Strong alkali**
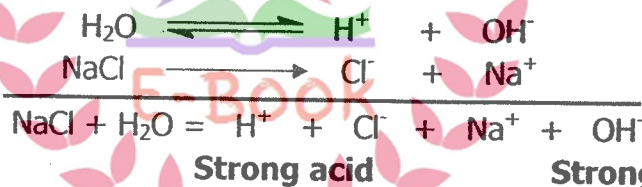
Concentration of (H^+) ions equals the concentration of (OH^-) ions and the solution is neutral.

2. Because the salt is derived from a weak acid (CH_3COOH) and a weak alkali (NH_4OH)

$$H_2O \rightleftharpoons \boxed{H^+} + \boxed{OH^-}$$
$$CH_3COONH_4 \longrightarrow \boxed{CH_3COO^-} + \boxed{NH_4^+}$$
$$CH_3COONH_4 + H_2O = CH_3COOH + NH_4OH$$

                Weak acid   **weak alkali**

Concentration of H^+ ions equals the concentration of OH^- ions and the solution is neutral.

3. Hydrochloric acid and sodium hydroxide are not formed on dissolving table salt in water, because they are completely ionized in water, while acetic acid and ammonium chloride are formed on dissolving ammonium acetate because it is partially ionized in water.

4. Because the hydrogen ion is attracted to the lone pair of electrons on the oxygen atom of the water molecule and connects to water molecule by a co-ordinate forming hydroxonium (Hydronium) ion $(H_3O)^+$.

5. Because the conc. of $[H^+]$ = the conc. of $[OH^-]$ = 10^{-7} mole/liter.

C) a) Solution of a pH 3.5.[Acidic solution]

   b) Solution of a pH 7. [Neutral solution]

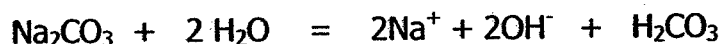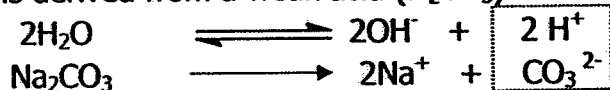c) Solution of a pH 4. [Acidic solution]

d) Solution of a pH 12.[Alkaline solution]

D) $BaSO_4 (s) \rightleftharpoons Ba^{2+} (aq) + SO_4^{2-} (aq)$

$K sp = [Ba^{2+}][SO_4^{2-}]$

$K sp = 1.04 \times 10^{-5} \times 1.04 \times 10^{-5} = 1.0816 \times 10^{-10}$

Answer of question (3)

A) 1. Because the salt is derived from a weak acid (H_2CO_3) and a strong alkali (NaOH)

$2H_2O \rightleftharpoons 2OH^- + \boxed{2 H^+}$

$Na_2CO_3 \longrightarrow 2Na^+ + \boxed{CO_3^{2-}}$

$Na_2CO_3 + 2 H_2O = 2Na^+ + 2OH^- + H_2CO_3$

Strong alkali   Weak acid

(OH^-) ions are found free and its concentration increases by the time and the solution is alkaline. [According to le Chatelier's principle]

2. Because the salt is derived from a strong acid (HCl) and a weak alkali (NH_4OH)

$H_2O \rightleftharpoons H^+ + \boxed{OH^-}$

$NH_4Cl \longrightarrow Cl^- + \boxed{NH_4^+}$

$NH_4Cl + H_2O = H^+ + Cl^- + NH_4OH$

Strong acid   weak alkali

H^+ ions remain free and increases by time in the solution and the solution is acidic. [According to le Chatelier's principle]

3. Because ammonium chloride solution is hydrolyzed in water giving ammonium hydroxide and hydrochloric acid which changes methyl orange solution to red..

4. Because the aqueous solution of hydrogen chloride is completely ionized in water ,while the aqueous solution of acetic acid is partially ionized in water.

5. Because water is neutral, the concentration of H^+ (responsible for the acidic properties) equals the concentration of OH^- (responsible for the basic properties).

B)

$[H^+]$	$[OH^-]$	pH	pOH
1×10^{-11}	1×10^{-3}	11	3
1×10^{-9}	1×10^{-5}	9	5
1×10^{-6}	1×10^{-8}	6	8
1×10^{-2}	1×10^{-12}	2	12

C) Ostawald

D)

$HCN + H_2O \rightleftharpoons H_3O^+ + CN^-$
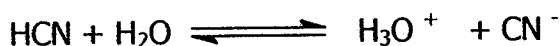
Applying Ostwald Law: $Ka = \alpha^2 \times C$

$7.2 \times 10^{-10} = \alpha^2 \times 0.1$

$\alpha^2 = \dfrac{7.2 \times 10^{-10}}{0.1} = 72 \times 10^{-10}$

$\alpha = \sqrt{72 \times 10^{-10}} = 8.5 \times 10^{-5}$

The degree of ionization of hydrogen ion = 8.5×10^{-5}

Answer of question (4)

A) 1. Ionic equilibrium: is the equilibrium which occurs between molecules of a weak electrolyte and the ions produced from it.

2. Ionic product of water (K_w): is resultant of multiplying the conc. of hydrogen

ion times that of hydroxide ion which equals to 10^{-14} mol/liter.

3. Solubility product: is the product of multiplication of the concentration of ions of sparingly soluble ionic compounds *(in mol/liter)*, each raised to the power of the number of ions, which exist in equilibrium with its saturated solution.

B) $NH_4Cl < NaCl < CH_3COONa$

C) a) $pH = -\log 10^{-5} = 5$ (acidic)

    b) $pH = -\log 10^{-12} = 12$ (alkaline)

    c) $pH = -\log 10^{-7} = 7$ (neutral)

D) $Al(OH)_3 \rightleftharpoons Al^{-3} + 3OH^-$

    $Ka = (Al^{-3}) \times (OH^-)^3$

    $Ka = (10^{-6}) \times (3 \times 10^{-6})^3 = 27 \times 10^{-24}$

Answer of question (5)

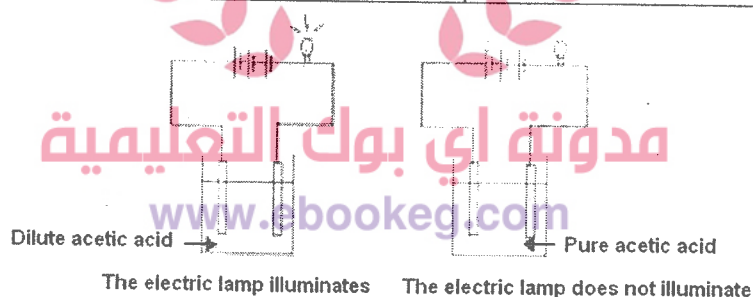**A)** 1. Alkaline.   2. Hydroxide.   3. Neutral.

    4. Acidic.   5. Ions

B) a. $H_2O \rightleftharpoons H^+ + OH^-$

    b. Ionic ionization

C) 1. Experiment	Ionic compound	Covalent compound
By passing electric current in each of them	Conducts electricity and the electric lamp illuminates	Does not conducts electricity and the electric lamp does not illuminates

2. Experiment	Dilute acetic acid	Pure acetic acid
By passing electric current in each of them	Conducts electricity and the electric lamp illuminates	Does not conducts electricity and the electric lamp does not illuminates

Dilute acetic acid →   ← Pure acetic acid

The electric lamp illuminates   The electric lamp does not illuminate

D) $NH_4OH \rightleftharpoons NH_4^+ + OH^-$

Applying Ostwald Law: $Ka = a^2 \times C$

              $1.6 \times 10^{-5} = a^2 \times 0.1$

$$a^2 = \frac{1.6 \times 10^{-5}}{0.1} = 1.6 \times 10^{-4}$$

$$a = \sqrt{1.6 \times 10^{-4}} = 0.0126$$

b- $[OH^-] = \sqrt{C_a \times K_a}$

         $= \sqrt{0.1 \times 1.6 \times 10^{-5}}$

         $= 1.3 \times 10^{-3}$ molar

c- $pOH = -\log (OH^-) = -\log 1.3 \times 10^{-3} = 2.9$

d- $pH = 14 - 2.9 = 11.1$

Exam (7) on galvanic cells

Answer four questions only of the following:

Question (1)

A) Choose the correct answer:

1. In the galvanic cell, the anode is the ....

  a- negative pole at which oxidation process takes place.

  b- negative pole at which reduction process takes place.

  c- positive pole at which reduction process takes place.

  d- positive pole at which oxidation process takes place.

2. If the reduction potential of sodium is (-2.71 volt), the element can ......

  a) replace hydrogen of water.   b) replace hydrogen of acids

  c) its oxidation potential (+2.71 volt). d) all the previous

3. Given the reaction: $Mg + Cl_2 \rightarrow MgCl_2$

  The half reaction which correctly represents the oxidation is ....

  a) $Mg + 2e^- \rightarrow Mg^{2+}$ b) $Cl_2 + 2e^- \rightarrow 2Cl^-$

  c) $Mg \rightarrow Mg^{2+} + 2e^-$ d) $Cl_2 \rightarrow 2Cl^- + 2e^-$

4. The quantity of electricity required to precipitate (9) gm from aluminum $^{27}Al_{13}$ by electrolysis of aluminum chloride. $AlCl_3$ solution equals to ....

  a) Faraday.   b) 2 Faraday.   c) 0.5 Faraday.   d) 3 Faraday.

5. In galvanic cells the chemical energy is converted to............Energy.

  a) Kinetic.   b) Electric.   c) Thermal.   d) Magnetic.

6. In lithium ion battery, the cathode is made of ......

  a) Lithium.   b) lithium phosphide.   c) Graphite lithium. d) Lithium cobalt oxide

B) Compare between:

1. Anodic cover and cathodic cover.

2. Mercury cell and fuel cell.

3. Primary cell and secondary cell.

C) Write one use of:

1. Lead accumulator (lead storage cell).

2. Standard hydrogen electrode.

D) (A) and (B) are two elements with oxidation potentials of (0.4) and (-0.6) volt, respectively. If both elements are divalent, what is the expression for the cell formed from both metals? **Calculate electromotive force** of the cell and show if electrical current is produced or not and why?

Question (2)

A) Write the suitable scientific expression for:

1. The system in which chemical energy is converted into electrical energy.

2. The descending arrangement of the standard oxidation potentials of the elements with reference to the standard hydrogen electrode.

3. A standard electrode, its potential equals zero.

4. The electrode at which oxidation process takes place in the electrochemical cells.

B) Draw a sector for the fuel cell illustrating all the parts on the figure.

C) Explain the role of each of the following:

1. Salt bridge in galvanic cell.

2. Dilute sulphuric acid in lead storage cell (car battery).

3. Lithium cobalt oxide in lithium ion battery.

4. Hydrated Potassium hydroxide in the fuel cell.

5. Potassium hydroxide in the mercury cell.

D) If the standard reduction potential for each of zinc and nickel is − 0.76 and +0.23 volt respectively.

a. Find e.m.f for the cell formed from both of them. 0.53 V

b. Write the symbolic representation of this cell. $Zn / Zn^{2+} // Ni^{2+} / Ni$

Question (3)

A) **Draw a labeled diagram for each of the following:**

1. Standard hydrogen electrode.

2. Lead acid battery

B) **Explain how** recharging of the car battery (lead storage cell) takes place and write the equation.

C) **Rewrite the following statements after correcting the underlined words:**

1. Concentration of sulphuric acid in the charged lead storage cell **equals** the concentration of the acid in the discharged cell.

2. In the fuel cell, **vessel contains oxygen** acts as anode.

3. **Sulphuric acid** is used as electrolyte in the mercury cell.

4. The standard hydrogen half cell is represented by the diagram: **Pt + H$_2$ (0.5atm.) /IH$^+$.**

D) **Write the expression** of the following galvanic cell and show the oxidizing agent. The given oxidation potential of zinc is 0.76 volt.

$$Zn + 2H^+ \longrightarrow H_2 + Zn^{2+}$$
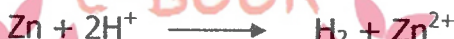
Question (4)

A) **What is meant by:**

1. Electrochemical series.
2. Oxidation-reduction reaction.

3. Charging the lead accumulator (car battery).
4. Primary cells.

5. Secondary cells.
6. Standard hydrogen electrode.

B) **Show by symbolic chemical equation:**

The total reaction occurring in the lithium ion battery.

C) 1. Mention the composition of the salt bridge of a galvanic cell and state its function.

2. What is the symbolic representation of the standard hydrogen electrode?

D) A galvanic cell, one of its electrodes is copper and the other one is silver. If you know that the standard reduction potentials for the two electrodes are 0.34 volt and 0.80 volt successively, calculate the e.m.f for this cell then write the equations for the spontaneous reaction at the anode and cathode.

Question (5)

A) **Give the scientific reason for each of the following:**

1. Copper cannot replace hydrogen of water or diluted acids while sodium replaces hydrogen of water and acids.

2. Fuel cell is considered one of the primary galvanic cells.

3. Mercury cell is basic whereas lead battery is acidic.

4. Anode is the negative pole in the galvanic cell.

5. Car battery (Galvanic cells) can be considered as a reversible cell.

B) Explain by symbolic equations what happens in the following cases: Immersion of a piece of zinc metal in copper sulphate solution for a long period of time.

C) Two metals A and B their standard oxidation potentials are - 0.3 and 0.7 volts respectively; each of them is divalent:

    1. Using a diagram how can you represent the cell which can be formed from these two metals?

    2. Calculate the electromotive force of this cell.

    3. Does this cell produce an electric current? Why?

D) Look at the opposite figure, then answer the following questions:
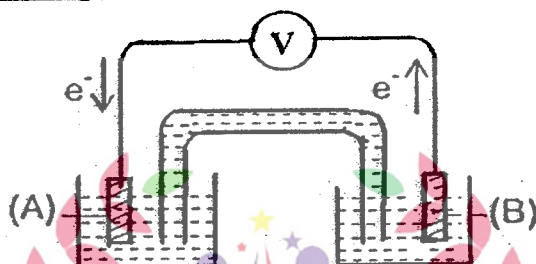
    1. What is the name of the electric cell shown in the figure?

    2. What is the type of (oxidation - reduction) reaction which takes place in the cell, **spontaneous** or **non-spontaneous** one?

    3. State which of the two poles (A) or (B) has the higher oxidation potential? And why?

    4. Show if this cell can be considered one of **the primary cells** or **the secondary cells**. And why?

Answer exam (7) on galvanic cells

Answer of question (1)

A)	1	2	3	4	5	6
	a	d	c	a	b	d

B) 1. P.O.C	Anodic cover	Cathodic cover
Definition	Covering the protective metal (e.g. iron) by another more active metal (e.g. zinc).	Covering the protective metal (e.g. iron) by another less active meta (e.g. tin).
Its effect	If the anodic cover (e.g. zinc) is scratched the protective metal (e.g. iron) starts its corrosion after the anodic cover is corroded completely.	If the cathodic cover (e.g. tin) is scratched the protective metal (e.g. iron) is corroded faster.
Example	Covering iron with zinc.	Covering iron with tin.

2. P.O.C	Mercury cell	Fuel cell
1. Type	Primary cell	Primary cell
1.Anode	zinc electrode	Vessel contains hydrogen

2.Cathode	Mercury oxide electrode	Vessel contains oxygen
3.Electolite	Potassium hydroxide	Hydrated KOH
4.E.M.F	1.35 volt	1.23 volt
5.The total reaction	$Zn^0 + HgO \rightarrow Zn\,O + Hg^0$	$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

3. Primary cell	Secondary cell
1. The (oxidation-reduction) reaction is irreversible.	1. The (oxidation-reduction) reaction is reversible.
2. cannot be recharged	2. can be recharged

3. **Example:** - Dry cell.
          - Mercury cell
	3. **Example:** - Lead acid battery.
	          - Alkaline nickel - cadmium battery

C) 1. Lead accumulator (lead storage cell) is used as a source of electric current.

2. Standard hydrogen electrode is used to determine the electric potential of the unknown electrodes.

D) Since the oxidation potential of element (A) is (0.4) volt and the oxidation potential of element (B) is (-0.6) volt, therefore the element (A) is the anode and the element (B) is the cathode.
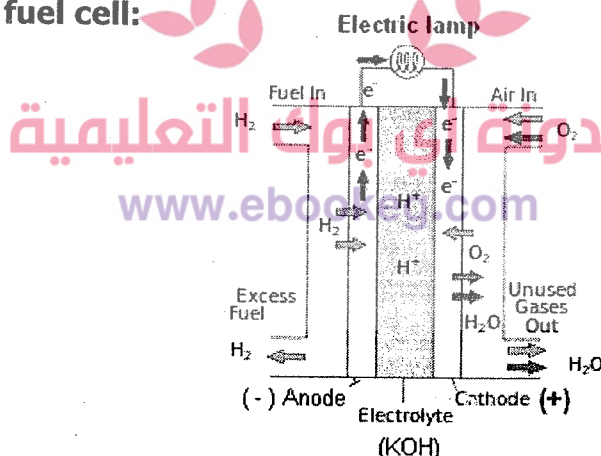
The symbol of the cell is: $A / A^{2+} // B^{2+} / B$

E.M.F of the cell = oxidation potential of (A) – oxidation potential of (B)

$= 0.4 - (- 0.6) = 0.4 + 0.6 = 1$ volt

So, the cell gives electric current because its E.M.F is positive.

Answer of question (2)

A) 1. Galvanic cells   2. Electromotive series

    3. Standard hydrogen electrode   4. The anode

B) Drawing of fuel cell:

C) 1. a. The salt bridge connects between the solutions of the two half cells without allowing a direct contact between them.

b. It neutralizes both the positive and negative charges which forms in the solutions of the two half cells as a result of the oxidation reduction reaction in the zinc and copper half cells.

2. It acts as electrolyte.

3. It acts as cathode.

4. It acts as electrolyte.

5. It acts as electrolyte.

D)	Anode	Cathode
	Zinc	Nickel
Oxidation potential	0.76	0.23
Reduction potential	- 0.76	- 0.23

a) e.m.f = oxidation potential of anode + reduction potential of cathode
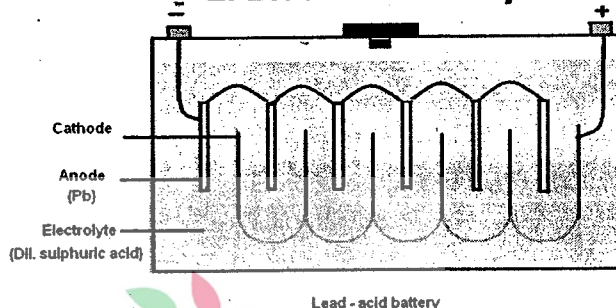   = 0.76 − 0.23 = 0.53 volt

b) Symbolic representation of the cell: $ZnIZn^{2+} // Ni^{2+}INi$

Answer of question (3)

A) 1. Standard hydrogen electrode: **2. Lead acid battery**

The standard hydrogen electrode
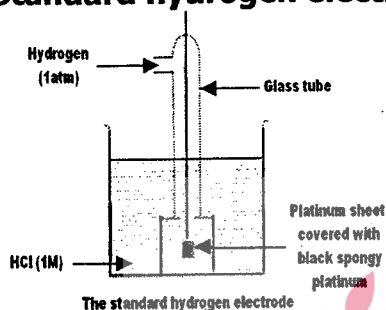
Lead - acid battery

B) The car battery poles are connecting to an outside source of direct electric current whose potential is slightly higher than the potential produced from the battery, so all reactions will be reversed at electrodes as follows:

$$2PbSO_4 + 2H_2O \xrightarrow{\text{Charge}} Pb + PbO_2 + 4H^+ + 2SO_4^{2-}$$

C) 1. Concentration of sulphuric acid in the charged lead storage cell **more than** the concentration of the acid in the discharged cell.

2. In the fuel cell, the **vessel contains hydrogen** acts as anode.

3. **Potassium hydroxide** is used as electrolyte in the mercury cell.

4. The standard hydrogen half cell is represented by the diagram: **$Pt + H_2$ (1 atm.) / H^+ (1M)**.

D) - The expression for the galvanic cell is: **$Zn / Zn^{2+} // 2H^+ / H_2$**
   - The oxidizing agent is hydrogen ions.

Answer of question (4)

A) 1. Electrochemical series: is arrangement of oxidation potentials of electrodes in a descending order as compared to standard hydrogen electrode.

2. Oxidation-reduction reaction: is a type of chemical reaction in which electrons transfer from one of the reacting substance to the other one in the same reaction.

3. Charging the lead accumulator (car battery): is a process in which the electrical energy is converted into chemical energy stored in the lead accumulator.

4. Primary cells: These are galvanic cells that can't be recharged where the chemical energy is stored and can be converted to electrical energy at the desired time.

5. Secondary cells: are Galvanic cells that can be recharged where the chemical energy is stored and can be converted to electrical energy at the desired time. Such as lead acid battery

6. Standard hydrogen electrode: is the electrode which has electric potential equals zero.

B) $\quad\quad$ $LiC_6(s) + CoO_2(s)$ $\quad$ $\xrightleftharpoons[\text{Charge}]{\text{Discharge}}$ $\quad$ $C_6(s) + LiCoO_2(s)$

C) Composition of the salt bridge:

It is a glass U-shaped tube filled with electrolyte solution (e. g Na_2SO_4) its ions do not react with the ions present in the two half cells as well as with the electrode materials of the galvanic cell.

Function of the salt bridge:

- The salt bridge connects between the solutions of the two half cells without allowing a direct contact between them.
- It neutralizes both the positive and negative charges which forms in the solutions of the two half cells as a result of the oxidation reduction reaction in the zinc and copper half cells.

D) E.M.F = $\quad 0.80 - 0.34 = 0.46$ volt

At the anode $\quad Cu \longrightarrow Cu^{2+} + 2e^-$

At the cathode $\quad 2Ag^+ + 2e^- \longrightarrow 2Ag$
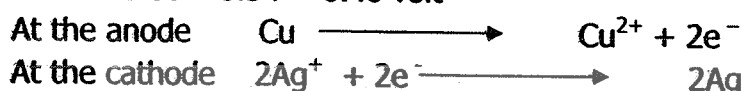
Answer of question (5)

A) 1. Because copper comes after hydrogen in the electromotive series of elements, but sodium comes before it.

2. Because it cannot be recharged (irreversible cell).

3. Because the electrolyte in mercury cell is (KOH) while the electrolyte in lead battery is (H_2SO_4)

4. Due to the accumulation of electrons resulting from the oxidation process on its surface.

5. Because when it is connected to an outside source of direct electric current whose potential is slightly higher than the potential produced from the battery, oxidation reactions are converted into reduction reactions and vise-versa.

B) When zinc rode is immersed in copper (II) solution salt:

- Copper metal starts to deposit on the Zn-sheet surface, while Zn-metal starts to dissolve in the solution.
- When we leave solution for a long time, the blue colour of copper sulphate solution decreases and perhaps becomes colourless and the dissolution of (Zn) increases.

This is due to a spontaneous oxidation-reduction reaction as follows:

- Oxidation reaction: $\quad Zn^o \longrightarrow Zn^{2+} + 2e^-$
- Reduction reaction: $\quad Cu^{2+} + 2e^- \longrightarrow Cu^o$

C) 1- $\quad$ $B / B^{+2} // A^{+2} / A$

2- e.m.f = standard oxidation potential of anode - standard oxidation potential of cathode

e.m.f = 0.7 - (- 0.3) = 1 volt

3- An electric current is produced because the e.m.f is positive value and the reaction inside the cell is spontaneous.

D) 1. Galvanic cell

2. Spontaneous oxidation-reaction

3. (B) has higher oxidation potential because the electricity passes from **(B)** to **(A)**.

4. Secondary cell because it can be recharged.

Exam (8) on electrolytic cells

Answer four questions only of the following:

Question (1)

A) Choose the correct answer:

1. When one Faraday is passed through an electrolyte, this will lead to the dissolution or evolution or deposition of..........from the substance at any electrode.
   a) gram atomic mass.
   b) gram equivalent mass.
   c) Avogadro's number mass.
   d) half gram equivalent mass.

2. For electroplating of a copper spoon with a layer of silver, we use........
   a) silver cathode in copper sulphate solution.
   b) silver anode in silver nitrate solution.
   c) silver cathode in silver nitrate solution
   d) copper anode in silver nitrate solution.

3. To precipitate one gram/atom of a trivalent metal in solution of one of its salts, the quantity of electricity needed equals ....
   a) 9650 coulombs.
   b) 96500 coulombs.
   c) 189000 coulombs.
   d) 289500 coulombs.

4. The quantity of electricity required to precipitate one gram/atom of aluminum metal according to the following reaction: $Al^{3+} + 3e^- \longrightarrow Al$ is equals to ....
   a) 0.5 faraday.
   b) 1 faraday.
   c) 3 faradays.
   d) 2 faradays.

5. The quantity of electricity required to precipitate one gram/atom of copper according to the following reaction: $Cu^{2+} + 2e^- \longrightarrow Cu$ is equal to ....
   a) faraday.
   b) 0.5 faraday.
   c) 2 faradays
   d) 4 faradays.

6. The quantity of electricity required to precipitate (18) gm from aluminum ($^{27}Al_{13}$) by electrolysis of aluminum chloride solution equals............
   a) 0.5 faraday.
   b) 1 faraday.
   c) 2 faradays.
   d) 9 faradays.

7. The quantity of electricity required to precipitate (9) gm from aluminum ($^{27}Al_{13}$) by electrolysis of aluminum chloride $AlCl_3$ solution equals ....
   a) faraday.
   b) 2 faraday.
   c) 0.5 faraday.
   d) 3 faraday.

8. To precipitate (4) gm of calcium metal (atomic mass of Ca = 40) as a result of electrolysis of molten calcium chloride ($CaCl_2$), the quantity of electricity required is..
   a) 96500 coulombs.
   b) 965 coulombs.
   c) 193 coulombs.
   d) 19300 coulombs

9. On electrolysis of aqueous solution of zinc chloride to precipitate 32.5 gram of zinc (Zn = 65), the quantity of electricity required equals...........
   a) 0.2 faraday.
   b) 2 faraday.
   c) 0.5 faraday.
   d) 1 faraday.

10. The mass of calcium element deposited from molten calcium chloride when passing 48250 coulombs equals .... (Atomic mass of Ca = 40)
   a) 40 grams
   b) 20 grams.
   c) 10 grams.
   d) 5 grams.

B) If you are given a copper spoon, explain with drawing what are the steps required to electroplate this spoon with a layer of silver.

C) Compare between: Galvanic cell and electrolytic cell.

D) Aluminum metal is produced from electrolysis of molten aluminum oxide. Calculate the number of aluminum moles produced when an electric current of intensity 9.65 amperes is passed for 5 minutes.
The cathode reaction equation is: $Al^{3+} + 3e^- \longrightarrow Al$ (Al = 27)

Question (2)

(A) Write the suitable scientific expression for:

1. Substances that conduct electric current through the movement of their ions.
2. The quantity of electricity consumed on passing a current with a strength of one ampere through a conducting solution for a time of one second.
3. Systems in which electrical energy is changed to chemical energy as a result of (oxidation - reduction) non spontaneous reactions.
4. Quantity of electricity required to precipitate 1.118 milligrams of silver.
5. The masses of the different materials formed or consumed by the same amount of electricity are proportional to their equivalent masses.
6. Quantity of electricity required to precipitate or dissolve equivalent mass in grams of any element during electrolysis.

B) The degree of purity of metals which are prepared in industry is usually lower than the required degree of purity which is required for definite purposes.
Explain by drawing how to obtain copper of 99.95% Purity degree.

C) How many minutes are necessary for the following to happen?
1. Production of 10500 coulombs from a current of 25 amperes strength.
2. Deposition of 21.9 g of silver from a solution of silver nitrate by passing a current of 10 amperes strength. (Ag = 108).

D) Calculate the volume of chlorine gas evolved at (S.T.P) during the electrolysis of sodium chloride (NaCl) solution by passing an electric current, its intensity is 10 amperes for 20 minutes.   (Cl = 35.45)
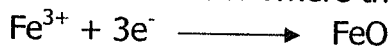
Question (3)

A) What is the scientific explanation for:

1. Copper is an electronic conductor, while copper sulphate solution is an electrolytic conductor.
2. A mixture of cryolite and fluorspar is added to bauxite during preparation of aluminum in industry.
3. Using a mixture of fluoride salts of aluminum, sodium and calcium instead of cryolite containing a little amount of fluorspar in the extraction of aluminum from bauxite.

B) What is the contribution of the scientist Faraday in the progress of chemistry?

C) What is the quantity of electricity in (coulombs) necessary to separate 11.2 gram of iron from a solution of iron III chloride? Where the cathode reaction is:

$$Fe^{3+} + 3e^- \longrightarrow FeO \qquad Fe = (55.86)$$

D) Calculate the mass of silver precipitated by the passage of an electric current of 10 amperes in a silver nitrate solution between two silver electrodes for half an hour. Write the cathode reaction.   (Ag = 108)

Question (4)

A) What is meant by:

1. Electrolytic cells.
2. Electroplating
3. First law of Faraday.
4. Second law of Faraday. And show how to achieve it practically.

B) Explain by drawing how you could obtain copper from copper II chloride solution

using graphite electrodes. Write the equation which shows oxidation-reduction reactions taking place at the anode and the cathode.

C) Calculate the time required to precipitate 9 grams of aluminum metal, when an electric current of strength 10 amperes is passed through an electrolytic cell contains aluminum oxide, knowing that ($^{27}A_{13}$) and the cathode reaction is:

$$Al^{3+} + 3e^- \longrightarrow Al$$
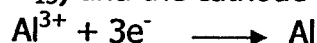
D) Calculate the mass of zinc metal precipitated at the cathode, knowing that an electric current of strength 20 amperes is passed through zinc sulphate solution (ZnSO$_4$) for ¼ hour. (Zn = 65)

Question (5)

A) Aluminum is electrically extracted from bauxite. Illustrate the following by the drawing and balanced chemical equations:

1- The oxidation reaction at anode.

2- The reduction reaction at cathode.

3- The total reaction.

4- Reaction of evolved oxygen at the carbon electrodes.

B) Calculate the mass of copper precipitated, when an electric current of strength 10 amperes is passed for ½ hour through the electrolytic cell of a solution of copper (II) sulphate. (Cu = 63.5)

C) How many minutes necessary to precipitate 3.175 grams of copper from copper (II) sulphate solution by passing an electric current of 10 amperes strength? (Cu = 63.5)

D) 1. What happens when an amount of electricity passes through different groups of electrolytic solutions connected in series?

2. What is meant by the gram equivalent mass of the substance?

3. On passing the same electric current in two solutions of silver nitrate AgNO$_3$ and copper II sulphate CuSO$_4$, the mass of deposited silver is 21.6 g. Calculate the mass of the deposited copper. [Cu = 63.5, Ag = 108]

> **Answer exam (8) on electrolytic cells**

Answer of question (1)

A) 1	2	3	4	5	6	7	8	9	10
b	b	d	c	c	c	a	d	d	c

B) (a) Clean the surface of the spoon completely.

(b) Dip the spoon into electrolyte solution that contains silver ions.

(c) Connect the spoon with the (-ve) electrode of the battery (cathode) and a rod of silver metal with the (+ve) electrode (anode).
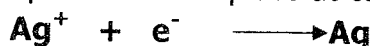
(d) Switch on the circuit.
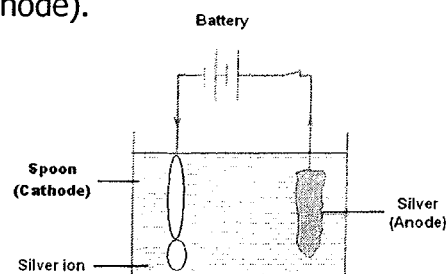
When the electric current passes through the circuit:

- Oxidation process takes place at anode.

$$Ag \longrightarrow Ag^+ + e^-$$

- Reduction process takes place at cathode.

$$Ag^+ + e^- \longrightarrow Ag$$

So, silver atoms precipitate on the surface of the spoon.

C) P.O.C	Galvanic cell	Electrolytic cell
1. Function	Converts chemical energy into electrical energy.	Converts electrical energy into chemical energy.
2. Anode	The negative electrode.	The positive electrode.
3. Cathode	The positive electrode.	The negative electrode.
4. Reactions	Spontaneous and reversible.	Non-spontaneous and irreversible.
5. E.M.F	Oxidation potential of anode + reduction potential of cathode.	The potential difference between the electrodes of the cell.

D) Quantity of electricity = electric current intensity x time

$$= 9.65 \times 5 \times 60 = 2895 \text{ coulombs}$$

Equivalent mass of Al = atomic mass / valency = 27/3 = 9 gram

96500 coulombs $\longrightarrow$ 9 grams Al

2895 coulombs $\longrightarrow$ (X) grams Al

$$X = \frac{2895 \times 9}{96500} = 0.27 \text{ gram}$$

27 grams Al $\longrightarrow$ 1 mole Al

0.27 gram Al $\longrightarrow$ (X) mole Al

$$(X) \frac{0.27 \times 1}{27} = 0.01 \text{ mole Al}$$

Answer of question (2)

A) 1. Electrolyte.   2. Coulomb.

3. Electrolytic cells.   4. Coulomb.

5. Faraday's second law.   6. Faraday.

B) (1) Impure copper metal is connected to the (+ve) electrode (anode) of the battery, while a wire of fine copper sheet is connected to the (-ve) electrode (cathode).

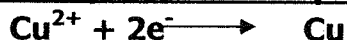(2) Both of the anode and cathode are dipped into a solution of copper sulphate. When the electric current passes:

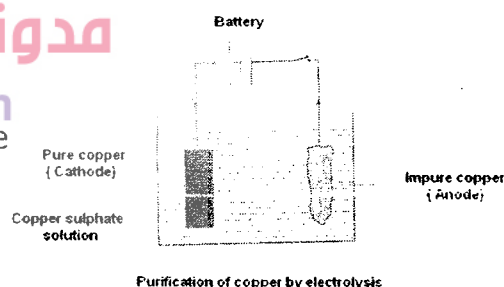- **Oxidation process takes place at anode:**

$$Cu \longrightarrow Cu^{2+} + 2e^-$$

Iron and zinc impurities dissolve in the solution while silver and gold impurities fail down the anode.

- **Reduction process takes place at cathode:**

$$Cu^{2+} + 2e^- \longrightarrow Cu$$

Pure copper atoms precipitate at cathode.

Battery

Pure copper (Cathode)

Copper sulphate solution

Impure copper (Anode)

Purification of copper by electrolysis

C) 1)

$$Q = I \times T$$

$$10500 = 25 \times T$$

$$T = \frac{10500}{25} = 420 \text{ seconds} = 7 \text{ minutes}$$

2) Equivalent mass $= \frac{108}{1} = 108$ g

(96500 coulomb) $\xrightarrow{\text{Precipitate}}$ 108 gram of silver

X $\xrightarrow{\text{Precipitate}}$ 21.9 gram of silver

Quantity of electricity (X) $= \frac{96500 \times 21.9}{108} = 19568.06$ coulomb

$$Q = I \times T$$
$$19568.06 = 10 \times T$$
$$T = \frac{19568.06}{10} = 1956.8 \text{ seconds} = 32.6 \text{ minutes}$$

D) The equivalent mass of chlorine = $\frac{35.45}{1}$ = 35.45 gm

The mass of chlorine = $\frac{10 \times 20 \times 60 \times 35.45}{96500}$ = 4.4 gm

The number of chlorine moles = $\frac{4.4}{70.9}$ = 0.062 moles

The volume of chlorine at S.T.P. = 0.062 × 22.4 = 1.3888 liters

Answer of question (3)

A)1. Copper is electronic conductor because the conductor takes place through the movement of electrons, while copper sulphate solution is electrolytic conductor. because the conductor takes place through the movement of its ions.

2. This is because the cryolite acts as a solvent, and the fluorspar decrease melting point of the mixture from 2045 °C to 950 °C.

3. Because cryolite decreases the melting point of bauxite only, While the fluoride mixture decreases the melting point and gives a mixture with lower density which facilitates the separation and precipitation of aluminum.

B) Faraday had deduced the relationship between the quantity of electricity which flow in solution and the quantity of material librated at electrodes. He summarized this relationship in two laws referred to his name.

C) Equivalent mass of iron = $\frac{\text{Atomic mass}}{\text{Valency}} = \frac{55.86}{3}$ = 18.62 grams

Quantity of electricity (coulomb) = $\frac{\text{Mass of deposited substance} \times 96500}{\text{Equivalent mass}}$

$$= \frac{11.2 \times 96500}{18.62} = 58045 \text{ coulomb}$$

D) Cathode reaction: $Ag^+ + e^- \longrightarrow Ag$

1/2 hour = 1/2 × 60 × 60 = 1800 second.

Mass of precipitate = $\frac{\text{Current strength (ampere)} \times \text{time (seconds)} \times \text{equivalent mass}}{96500}$

Mass of precipitate = $\frac{10 \times 1800 \times 108}{96500}$ = 20.15 gm.

Answer of question (4)

A) 1. Electrolytic cells: are cells that convert electrical energy to chemical energy through non-spontaneous oxidation-reduction reaction.

2. Electroplating: is a process of formation of thin layer of certain metal on the surface of another metal to give it an attractive appearance or protect it from corrosion.

3. First law of Faraday: states that "the quantity of formed or consumed material at any electrode is directly proportional to the quantity of electricity passing through solution".

4. Second law of Faraday: states that "The masses of different materials formed or consumed by the same amount of electricity are directly proportional to their equivalent masses".

Achieving Second law of Faraday practically:

- Pass the same quantity of electricity in different groups of solutions such as aluminum chloride, silver nitrate and copper sulphate.

Electrolysis of different electrolytic solutions
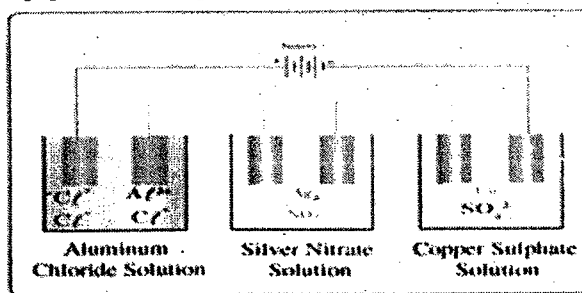
Observation:

The masses of the formed materials at the cathode in the cells which are: aluminum, silver and copper, respectively are proportional to their equivalent masses i.e. in the ratio: $9: 107.88: 31.78$ respectively which realize Faraday second law.
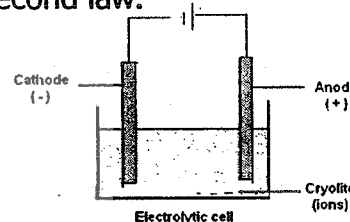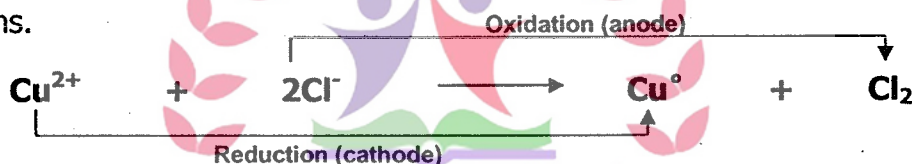
B) $$CuCl_2 \longrightarrow Cu^{2+} + 2Cl^-$$
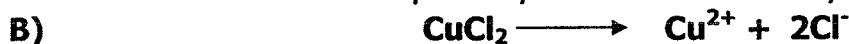
At the anode (positive electrode)

$$2Cl^- \xrightarrow{\text{Oxidation}} Cl_2 + 2e^-$$

At the cathode (negative electrode)

$$Cu^{2+} + 2e^- \xrightarrow{\text{Reduction}} Cu^\circ \downarrow$$

And the total reaction occurs in the cell is the sum of the anode and cathode reactions.

$$Cu^{2+} + 2Cl^- \xrightarrow{\text{Oxidation (anode)}} Cu^\circ + Cl_2$$
Reduction (cathode)

C) Equivalent weight of $Al = \dfrac{27}{3} = 9$

$$96500\ C \xrightarrow{\text{Precipitate}} 9\ gm.$$
$$X \xrightarrow{\text{Precipitate}} 9\ gm$$

$$x \text{ (Quantity of electricity)} = \frac{96500 \times 9}{9} = 96500\ C$$

Quantity of electricity $= I \times t$

$$96500 = 10 \times t$$

$$t = \frac{96500}{10} = 9650 \text{ seconds.}$$

D) Quantity of electricity $= I \times t$

$$= 20 \times \left(\frac{1}{4} \times 60 \times 60\right) = 18000 \text{ Sec.}$$

equivalent mass of $Zn = \dfrac{65}{2} = 32.5\ g$

$$96500 \text{ Coulombs} \xrightarrow{\text{Precipitate}} 32.5 \text{ gm. of } Zn$$
$$18000 \text{ Coulombs} \xrightarrow{\text{Precipitate}} (X) \text{ gm. of } Zn$$

The weight of zinc metal precipitated at the cathode $= \dfrac{18000 \times 32.5}{96500} = 6.0621762\ gm$
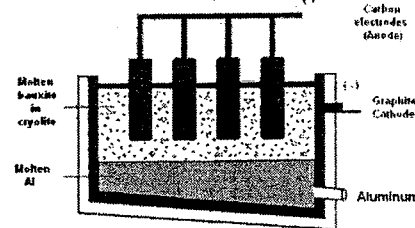
Answer of question (5)

A) (1) The body of the container which is made from iron plated by a layer of carbon (graphite) is connected to the negative electrode of the electric source and acts as cathode.

(2) Carbon rods are connected to the positive electrode of the electric source and acts as anode.

- When the electric current passes between the cell electrodes an oxidation-reduction reaction occurs:

$$Al_2O_3 \longrightarrow 2Al^{3+} + 3O^{2-}$$

At the anode (+ve) $\quad 3O^{2-} \longrightarrow 3/2\ O_2 + 6e^-$

At the cathode (-ve): $\quad 2Al^{3-} + 6e^- \longrightarrow 2Al$

And the total reaction is: $2Al^{3-} + 3O^{2-} \longrightarrow 2Al + 3/2O_2$

Then aluminum is withdrawn from the cell through a special opening.

Main point: - The evolved oxygen reacts with the carbon rods forming carbon monoxide and carbon dioxide gases.

$$2C + 3/2\ O_2 \xrightarrow{\ \Delta\ } CO + CO_2$$
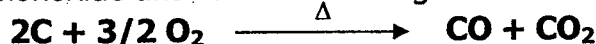
B) The current strength = I x t

$$= 10 \times (30 \times 60) = 18000\ sec.$$

The equivalent weight of cu II = $\dfrac{63.5}{2}$ = 31.75

96500 C $\xrightarrow{\text{Precipitate}}$ 31.75

18000 C $\xrightarrow{\text{Precipitate}}$ X

The mass of copper (x) = $\dfrac{18000 \times 31.75}{96500}$ = 5.9 gm

C) Equivalent mass of copper = $\dfrac{63.5}{2}$ = 31.75 g

96500 coulomb $\xrightarrow{\text{Precipitate}}$ 31.75 g of copper

(x) coulomb $\xrightarrow{\text{Precipitate}}$ 3.175 g of copper

Quantity of electricity = $\dfrac{3.175 \times 96500}{31.75}$ = 9650 C

$$Q = I \times t$$
$$9650 = 10 \times t$$
$$Time = \dfrac{9650}{10 \times 60} = 16.083\ min.$$

D) 1. The masses of the formed materials at the cathode in the cells are proportional to their equivalent masses.

2. **The gram equivalent mass of the substance:**

It is the mass of substance that has the ability to lose or gain one mole of the electrons during the chemical reaction.

The mathematical formula:

The gram equivalent mass = $\dfrac{\text{The gram atomic mass}}{\text{Number of charges on the ion of the element (Z)}}$

3. Equivalent mass of Ag = $\dfrac{108}{1}$ = 108 g

Equivalent mass of Cu = $\dfrac{63.5}{2}$ = 31.75 g

$$\dfrac{\text{Mass of deposited Ag}}{\text{Mass of deposited Cu}} = \dfrac{\text{Equivalent mass of Ag}}{\text{Equivalent mass of Cu}}$$

$$\dfrac{21.6}{\text{Mass of deposited Cu}} = \dfrac{108}{31.75}$$

Mass of deposited Cu = $\dfrac{21.6 \times 31.75}{108}$ = 6.35 g

Exam (9) on aliphatic hydrocarbons

Answer four only of the following questions

Question (1)

A) Choose the correct answer:

1. Thermal catalytic cracking of octane (C_8H_{18}) gives ....
   - a- hexane + ethane.
   - b- butene + butane.
   - c- heptane + methane.
   - d- butane + pentene

2. Catalytic hydration of acetylene followed by oxidation of the product gives .....
   - a- methanoic acid.
   - b- ethanal.
   - c- methanol.
   - d- ethanoic acid

3. Dry distillation of anhydrous sodium acetate with soda lime gives ......
   - a- formaldehyde.
   - b- acetaldehyde.
   - c- ethanol.
   - d- methane.

4. The number of hydrogen atoms in the alkane molecule which consists of 4 carbon atoms is ....atoms.
   - a- 5.
   - b- 10.
   - c- 7.
   - d- 8.

5. The .... is used in pipe plastic industry:
   - a- Poly ethylene.
   - b- PVC (polyvinyl chloride).
   - c- Poly Propylene.
   - d- Polytetra- fluoroethene.

6. When hydrobromic acid reacts with propene .... is produced.
   - a- propyl bromide
   - b- 1,2 dibromopropene
   - c- 2-bromopropane
   - d- 1-bromopropane

B) Show by symbolic equations how you can obtain:

1. Ethanoic aced from calcium carbide.
2. Ethylene glycol from ethanol.
3. Black carbon from sodium acetate.
4. Water gas from sodium acetate.
5. Chloroform from methane.

C) How can you differentiate between:

1. Methane and ethene (ethylene) by two different methods.
2. Methane and ethyne (acetylene).
3. Ethyne and ethane.

Question (2)

A) Explain by symbolic chemical equations what happens in each of the following cases:

1. Hydrolysis of ethyl hydrogen sulphate.
2. Oxidation of ethene by potassium permanganate in an alkaline medium.
3. Dropping water on calcium carbide, then catalytic hydration of the product.
4. Burning acetylene in excess amount of oxygen.

B) Write the scientific expression for each of the following:

1. The similarity of some organic compounds in the molecular formula but differs in the structural formula
2. The reaction of alkenes with potassium permanganate solution in alkaline medium to give dihydric alcohols.
3. The rule used on the addition of an unsymmetric reagent (HX) to an unsymmetric alkene.

4. Easy liquefied halogenated alkanes used in manufacture of cooling systems.

5. Saturated aliphatic hydrocarbons their general formula is C_nH_{2n}.

C) Compare between:

1) Organic and inorganic compounds.

2) Addition polymerization and condensation polymerization.

D) 1- What is the molecular formula of an alkane having 17 atoms?

   2- What is the number of hydrogen atom in an alkene having 18 atoms?

   3- What is the number of carbon atoms in an alkyne having 13 atoms?

   4- What is the number of sigma bonds found in acetylene?

Question (3)

A) Ethyne gas reacts with hydrogen bromide gas in two steps.

1- Why the reaction takes place in two steps?

2- Write the two balanced chemical equations for this reaction.

3- Mention IUPAC nomenclature of the final product.

4- What happens on adding 5 moles of hydrogen bromide to 1 mole of Ethyne at (STP)?

B) How can you practically test for the presence of carbon and hydrogen elements in an organic compound? Write the symbolic equations and draw the apparatus used.

C) What is the role of each of the following:

1. Potassium permanganate in Baeyr's reaction.

2. Sulphuric acid in addition of water to ethene.

D) Write the structural formula of:

1) 1- chloro-2- methyl butane.

2) 2, 2-dimethyl propane.

3) Ethyl hydrogen sulphate.

4) 3-methyl hexane.

5) 3-methyl-1-pentene.

6) 4-chloro-4-methyl-2-pentene.

Question (4)

A) Write the structural formula of the compound 3-Methyl-1-butene then explain:

1. What is the number of hydrogen moles required to react with one mole of this compound to obtain saturated compound?

2. Show by chemical equation the reaction of this compound with potassium permanganate in alkaline medium.

B) What is meant by:

1. Markownikoff's rule.

2. Catalytic hydration of alkenes.

3. Catalytic hydration of acetylenes.

4. Homologous series.

5. Alkyl group.

C) Using the following: Anhydrous sodium acetate-calcium carbide - caustic soda - calcium oxide - copper sulphate solution - ethyl alcohol- water- concentrated sulphuric acid.

How can you prepare the following compounds?

(Write the symbolic reaction equations and state the conditions of each reaction)

1. Acetylene gas and draw the apparatus used for laboratory preparation.
2. Methane gas and draw the apparatus used for laboratory preparation.
3. Ethene gas and draw the apparatus used for laboratory preparation.

D) Write the structural formula of:

1) The product obtained by evaporating ammonium cyanate solution.
2) A compound from alkanes its molecule contains six carbon atoms and does not contain methene ($-CH_2$) group.
3) A compound used as an antifreeze material in car radiators in cold regions.
4) A compound used as a safe anesthetic substance.

Question (5)

A) Give reasons for:

1. Alkanes are saturated compounds while alkenes are unsaturated compounds.
2. Alkynes react by addition in two steps, whereas the addition reaction of alkenes takes place in one step.
3. Halothane is preferred over chloroform as anesthetic.
4. The presence of a huge number of organic compounds.
5. The failure of vital force theory by Wohler's experiment.
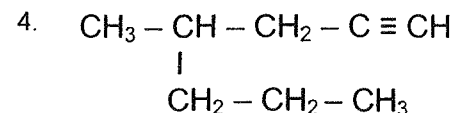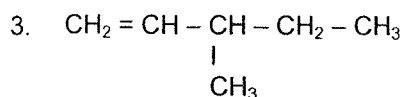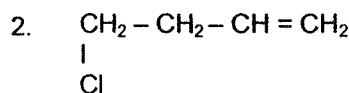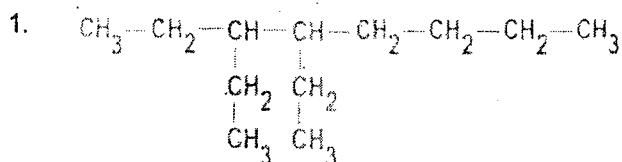6. Ethanol and dimethyl ether are isomers.

B) Explain by symbolic chemical equations what happens in each of the following cases:

1. Dehydration of ethyl alcohol by concentrated sulphuric acid at 180 °C.
2. Thermal catalytic cracking of octane. (What is the importance of this reaction?)
3. Dry distillation of anhydrous sodium acetate.
4. Heating natural gas at temperature higher than 1400 °C, then fast cooling of the product.

C) The molecular mass of a hydrocarbon is 58 grams, its mole contains 48 grams carbon. (H = 1, C = 12)

1. Write the molecular formula for this compound.
2. This compound has two isomers (isomerism), write the structural formula for each isomer.

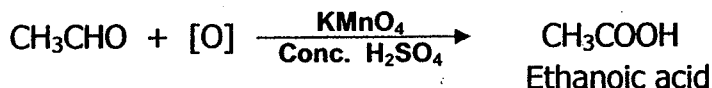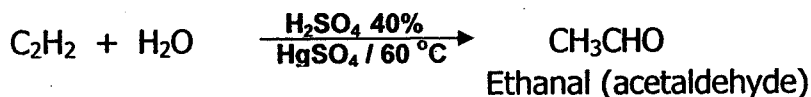### D) Write the chemical name according to IUPAC system for each of the following compounds:

1.
$$CH_3 - CH_2 - CH - CH - CH_2 - CH_2 - CH_2 - CH_3$$
$$\quad\quad\quad\quad | \quad\quad\; |$$
$$\quad\quad\quad\quad CH_2 \;\; CH_2$$
$$\quad\quad\quad\quad | \quad\quad\; |$$
$$\quad\quad\quad\quad CH_3 \;\; CH_3$$

2.
$$CH_2 - CH_2 - CH = CH_2$$
$$|$$
$$Cl$$

3.
$$CH_2 = CH - CH - CH_2 - CH_3$$
$$\quad\quad\quad\quad | $$
$$\quad\quad\quad\quad CH_3$$

4.
$$CH_3 - CH - CH_2 - C \equiv CH$$
$$\quad\quad\quad | $$
$$\quad\quad\quad CH_2 - CH_2 - CH_3$$

Answer of question (1)

A) 1	2	3	4	5	6
b	d	d	b	b	c

B) 1. Ethanoic aced from calcium carbide.

$$CaC_2 + 2H_2O \xrightarrow{\text{Dropping}} C_2H_2 + Ca(OH)_2$$

$$C_2H_2 + H_2O \xrightarrow[\text{HgSO}_4 / 60\,^{\circ}\text{C}]{\text{H}_2\text{SO}_4\ 40\%} CH_3CHO$$
Ethanal (acetaldehyde)

$$CH_3CHO + [O] \xrightarrow[\text{Conc. H}_2\text{SO}_4]{\text{KMnO}_4} CH_3COOH$$
Ethanoic acid

2. Ethylene glycol from ethanol.

$$C_2H_5OH \xrightarrow[\text{180 }^{\circ}\text{C}]{\text{Conc. H}_2\text{SO}_4} C_2H_4 + H_2O$$

$$C_2H_4 + H_2O + [O] \xrightarrow[\text{Alkaline medium}]{\text{KMnO}_4} C_2H_4(OH)_2 \quad [\text{ethylene glycol}]$$

3. Black carbon from sodium acetate.

$$CH_3COONa + NaOH \xrightarrow[\triangle]{\text{CaO}} CH_4 + Na_2CO_3$$

$$CH_4 \xrightarrow[\text{In absence of air}]{\text{1000 }^{\circ}\text{C}} C + 2H_2$$
(Black carbon)

4. Water gas from sodium acetate.

$$CH_3COONa + NaOH \xrightarrow[\triangle]{\text{CaO}} CH_4 + Na_2CO_3$$

$$CH_4 + H_2O \xrightarrow[\text{Catalyst}]{\text{725 }^{\circ}\text{C}} \underbrace{CO + 3H_2}_{\text{Water gas}}$$

5. Chloroform from methane.

$$CH_4 + Cl_2 \xrightarrow{\text{UV or 400 }^{\circ}\text{C}} CH_3Cl + HCl$$

$$CH_3Cl + Cl_2 \xrightarrow{\text{UV or 400 }^{\circ}\text{C}} CH_2Cl_2 + HCl$$

$$CH_2Cl_2 + Cl_2 \xrightarrow{\text{UV or 400 }^{\circ}\text{C}} CHCl_3 + HCl$$
(Chloroform)

C) 1. Experiment	Methane gas	Ethene (ethylene) gas
a) By adding bromine dissolved in (CCl_4) to each of them.	No effect	The red colour of bromine disappears
b) By adding $KMnO_4$ in an alkaline medium to each of them	No effect	The violet colour of $KMnO_4$ disappears.

$$C_2H_4 + H_2O + [O] \xrightarrow[\text{Alkaline medium}]{\text{KMnO}_4} C_2H_4(OH) \quad \text{ethylene glycol}$$

2. Experiment	Methane gas	Ethyne (acetylene) gas
By adding bromine dissolved in ($CCl4$) to each of them.	No effect	The red colour of bromine disappears

3. Experiment	Ethane gas	Ethyne (acetylene) gas
By adding bromine dissolved in (CCl_4) to each of them.	No effect	The red colour of bromine disappears.

Answer of question (2)

A) 1. $CH_3-CH_2-OSO_3H + H_2O \xrightarrow[110°C]{Heat} CH_3-CH_2-OH + H_2SO_4$

2. $C_2H_4 + H_2O + [O] \xrightarrow[\text{Alkaline medium}]{KMnO_4} C_2H_4(OH)_2$ [ethylene glycol]

3. $CaC_2 + 2H_2O \xrightarrow{Dropping} C_2H_2 + Ca(OH)_2$

$C_2H_2 + H_2O \xrightarrow[HgSO_4/60°C]{H_2SO_4\ 40\%} CH_3CHO$

4. $2C_2H_2(g) + 5O_2(g) \xrightarrow[\text{Excess oxygen}]{Heat} 4CO_2(g) + 2H_2O(g) + Energy$
   Pure oxygen
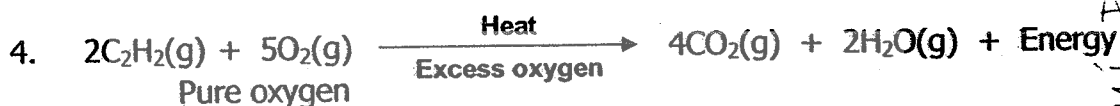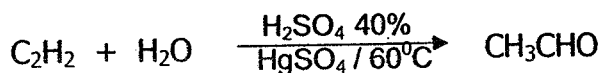
B) 1. Isomerism.   2. Baeyer's reaction.   3. Markonikoff's rule.
   4. Freons.   5. Cyclo alkane.

C) 1. Property	Organic compounds	Inorganic compounds
1- Chemical structure	Mainly contain carbon atoms.	May contain carbon atoms in addition to other elements.
2- Solubility	most are Insoluble in water but soluble in organic solvent e.g. benzene	most are soluble in water
3- Melting point	low.	high
4- Boiling point	low.	high
5- The odour	Most have characteristic odour.	most are odourless
6- Inflammability	inflammable and produce CO_2, H_2O	not inflammable, if it is inflammable it produces other gases
7- Kinds of bonds in the molecule	covalent bonds	Ionic bonds
8- Conductivity	Do not conduct electricity.	usually electrolytic compounds conduct electricity
9- Rate of chemical reaction	slow, because it takes place between the molecules	Fast, because it takes place between the ions.
10- Polymerization	can be polymerized	can't be polymerized
11-Isomerism	It is found among many compounds	It is not found among their compounds.

2. Addition polymerization	Condensation polymerization
Combination of a large number of unsaturated simple molecules (monomers) to give a giant molecule (polymer) having the same empirical formula.(e.g. Ethylene glycol)	Condensation of two different monomers to give a new monomer called copolymer which undergoes polymerization (e.g. Dacron)

D) 1. $n + 2n + 2 = 17$

$\qquad 3n = 17 - 2$

$\qquad 3n = 15$

$\qquad n = 5$

Number of C atoms = 5, Number of H atoms = 12

Molecular formula is C_5H_{12}

2. $n + 2n = 18$

$\qquad 3n = 18$

$\qquad n = 6$

Number of C atoms = 6, Number of H atoms = 12
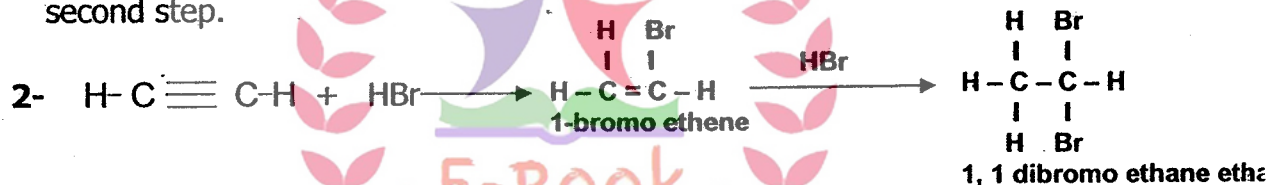
3. $n + 2n - 2 = 13$

$\qquad 3n = 15$

$\qquad n = 5$

Number of C atoms = 5

**4.** Three sigma bonds.

Answer of question (3)

A) 1- The reaction of ethyne with hydrogen bromide takes place at two steps where the triple bond changes to double bond in first step then to single bond in the second step.

2-

$$H-C \equiv C-H \ + \ HBr \longrightarrow \underset{\text{1-bromo ethene}}{H-C=C-H} \ \xrightarrow{HBr} \ H-C-C-H$$

(with H, Br substituents)

1, 1 dibromo ethane

3- The name of the compound resulted according to IUPAC system is: 1,1 dibromo ethane

4- When 5 moles of hydrogen bromide is added to 1 mole of ethyne then 2 moles only are reacted and 3 moles of hydrogen bromide are remained without reaction.

B) Detection of Carbon and hydrogen in organic compounds:
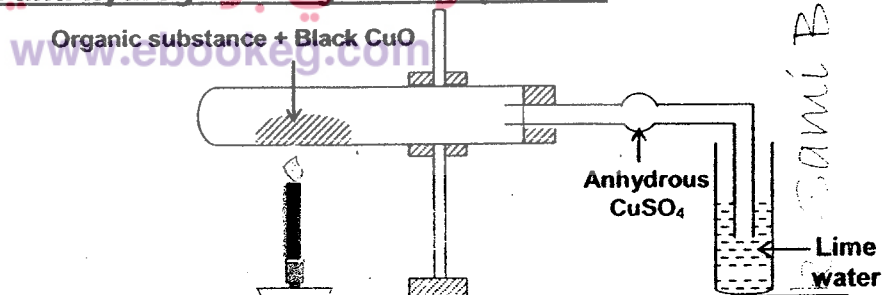
Organic substance + Black CuO

Anhydrous CuSO₄

Lime water

Experiment:-

1. Heat the organic substance with copper oxide [CuO]

2. Pass the resulting gases over white copper sulphate, then through lime water.

Observation: - The white copper sulphate turns blue.

- The lime water becomes milky.
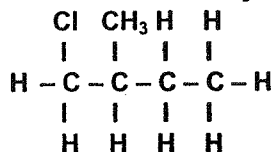
Conclusion: The organic substance contains:-

- Carbon which is oxidized to carbon dioxide makes lime water milky.

- Hydrogen which is oxidized to water changes the white $cuso_4$ into blue Cu SO₄

$$C \ + \ 2CuO \ \xrightarrow{Heat} \ CO_2 + 2Cu$$

$$2H \ + \ CuO \ \xrightarrow{Heat} \ H_2O + Cu$$
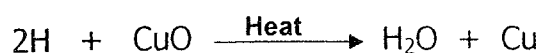
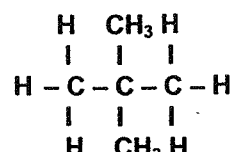C) 1. It acts as an oxidizing agent.

   2. Because water is a weak electrolyte, so sulphuric acid is added to increase the concentration of hydrogen ions to be able to break down the double bond present in ethene.
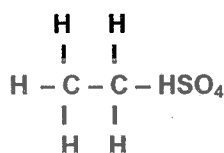
D) 1) 1- chloro-2- methyl butane

```
    Cl  CH₃ H   H
    |    |  |   |
H – C  – C – C – C – H
    |    |  |   |
    H    H  H   H
```
1- Choloro-2-methyl butane

2) 2, 2-dimethyl propane

```
    H   CH₃ H
    |    |  |
H – C  – C – C – H
    |    |  |
    H   CH₃ H
```
2, 2-dimethyl propane

3) Ethyl hydrogen sulphate.

```
    H   H
    |   |
H – C – C – HSO₄
    |   |
    H   H
```
Ethyl hydrogen sulphate

4) 3-methyl hexane

```
    H   H  CH₃ H   H   H
    |   |   |  |   |   |
H – C – C – C – C – C – C – H
    |   |   |  |   |   |
    H   H   H  H   H   H
```
3-methyl hexane

5) 3-methyl-1-pentene.

```
    H   H  CH₃ H   H
    |   |   |  |   |
H – C = C – C – C – C – H
    |       |  |   |
    H       H  H   H
```
3-methyl -1-pentene
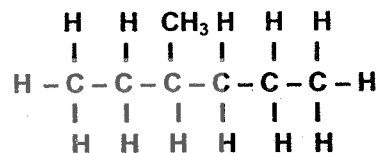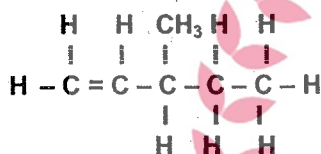
6) 4-chloro-4-methyl-2-pentene.
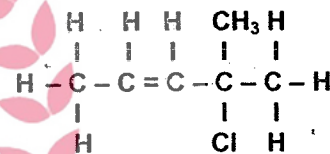
```
    H   H   H  CH₃ H
    |   |   |   |  |
H – C – C = C – C – C – H
    |           |  |
    H          Cl  H
```
4-chloro-4-methyl-2-pentene

Answer of question (4)

A) 1-

```
    H   H   H   H
    |   |   |   |
H – C – C – C = C – H
    |   |
    H   CH₃
```

2- 1 mole

3-

```
    H   H  H  H                                      H   H   H   H
    |   |  |  |                                      |   |   |   |
H – C – C – C = C – H   + H₂O + [O]  ──KMnO₄──►   H – C – C – C – C – H
    |   |                    Alkaline medium          |   |   |   |
    H   CH₃                                           H   CH₃ OH  OH
```
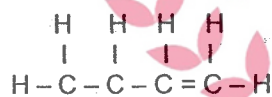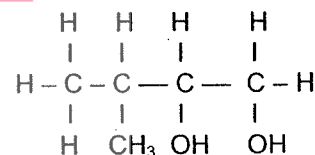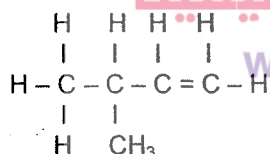
B) 1. Markonikoff's rule: The rule that governed the addition of unsymmetrical reagent (HX) to asymmetric alkenes. It states that "On adding an asymmetric reagent (HX) to an reagent, the positive part is added to carbon atom which carries a large number of hydrogen atoms and the negative part is added to the carbon atom which carries less number of hydrogen atoms".

 **2. Catalytic hydration of alkenes:** Addition of water to alkenes in the presence of a catalyst.

  3. Catalytic hydration of acetylenes: Addition of water to acetylene in the presence of a catalyst.

  4. Homologous series: is a group of compounds having the same general molecular formula and the same chemical properties with graduated physical properties.
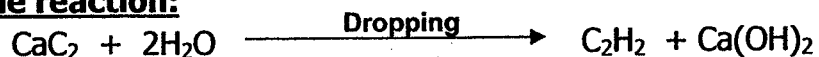
  5. Alkyl group: is an organic atomic group which doesn't found alone and obtain by removal one hydrogen atom from alkane.
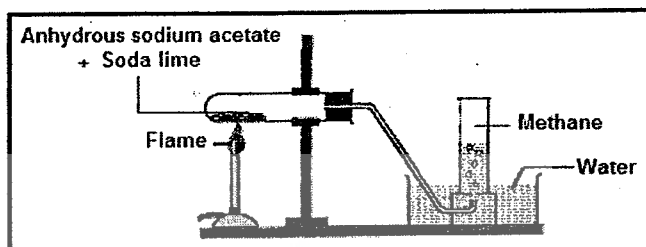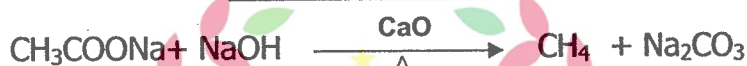
C) 1. Preparation of acetylene in laboratory:
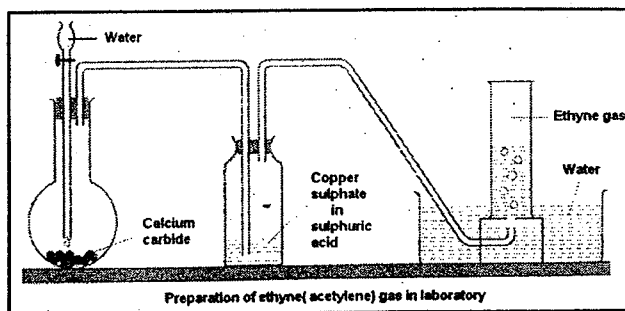
Preparation of ethyne(acetylene) gas in laboratory

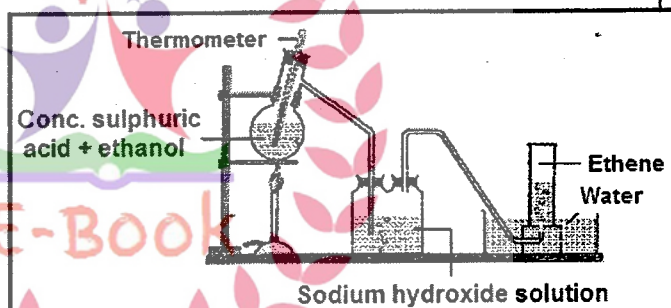### Equation of the reaction:

$$CaC_2 + 2H_2O \xrightarrow{\text{Dropping}} C_2H_2 + Ca(OH)_2$$

2. Preparation of methane in laboratory:

Equation of reaction:

$$CH_3COONa + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$

3. Preparation of Ethene in laboratory:

Equation of reaction:

$$C_2H_5OH \xrightarrow[180\,°C]{Conc.H_2SO_4} C_2H_4 + H_2O$$

D) 1.

```
        CH₃  CH₃
         |    |
CH₃ – C —— C – CH₃
         |    |
         H    H
```
1,2 dimethyl butane

2.
```
     H   O   H
     |   ||  |
H – N – C – N – H
```
Urea

3.
```
      H   H
      |   |
H – C —— C – H
      |   |
      OH  OH
```
Ethylene glycol

4.
```
     Br   F
     |    |
H – C —— C – F
     |    |
     Cl   F
```
Halothane
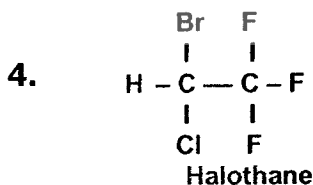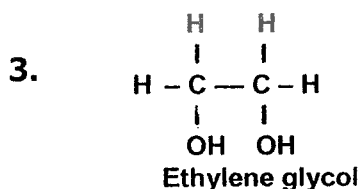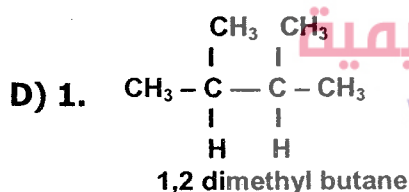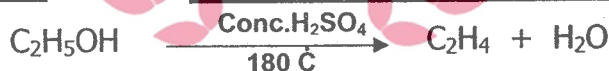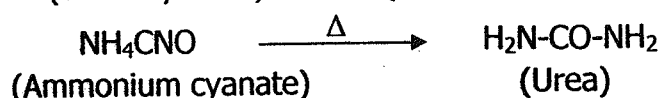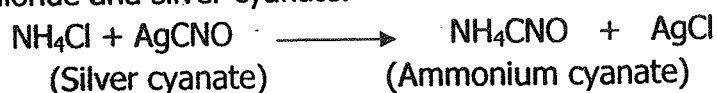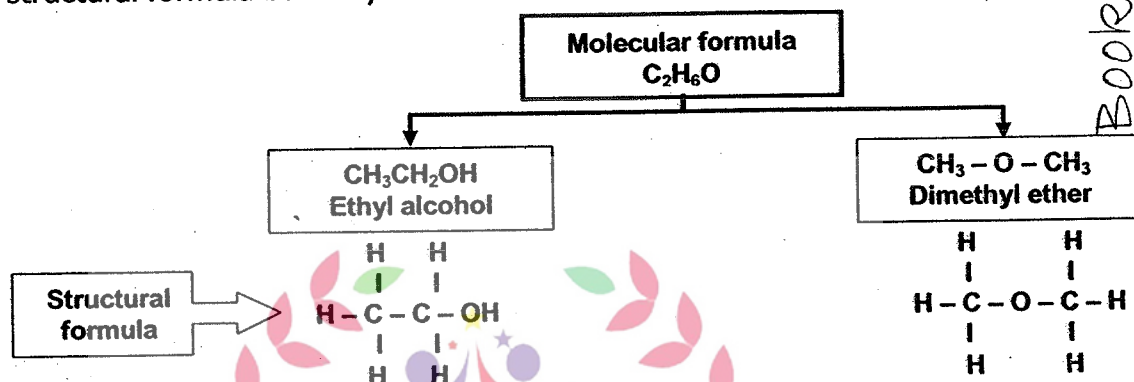
Answer of question (5)

A) 1. Alkanes are saturated hydrocarbons because all bonds are single of sigma type, while alkynes are unsaturated hydrocarbons because there is a double bond between the two carbon atoms.

2. This is because the inaccurate dose of chloroform causes death.

3. Due to the ability of carbon atoms to combine with each other or with other atoms by different types of bonds, through straight chains, branched chains, cyclic and aromatic compounds.

4. Because the German scientist Wohler destroyed the vital force theory, when he prepared urea by heating an aqueous solution of two inorganic compounds, ammonium chloride and silver cyanate.

$$NH_4Cl + AgCNO \longrightarrow NH_4CNO + AgCl$$
(Silver cyanate)　　　　(Ammonium cyanate)

$$NH_4CNO \xrightarrow{\;\Delta\;} H_2N-CO-NH_2$$
(Ammonium cyanate)　　　　(Urea)

5. Because they are different in the physical and chemical properties and also in structural formula but they have the same molecular formula.

B) 1. **Dehydration of ethyl alcohol by concentrated sulphuric acid at 180 °C.**

$$C_2H_5OH \xrightarrow[\text{Conc.}H_2SO_4]{180\,C} C_2H_4 + H_2O$$

2. **Thermal catalytic cracking of octane.**

$$C_8H_{18} \xrightarrow[\text{Catalyst}]{\text{Pressure / temp.}} C_4H_8 + C_4H_{10}$$
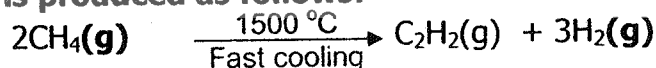　　　　　　　　　　　　　Butene　　Butane

The importance of this reaction:

This process usually takes place during the refining of petroleum oil to convert the heavy long petroleum chains (kerosene and mazoute) to the daily used lighter short chain products such as gasoline.

3. **Dry distillation of anhydrous sodium acetate.**

$$CH_3COONa + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$

4. **Ethyne gas is produced as follows:**

$$2CH_4(g) \xrightarrow[\text{Fast cooling}]{1500\,^{\circ}C} C_2H_2(g) + 3H_2(g)$$
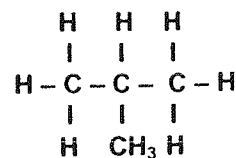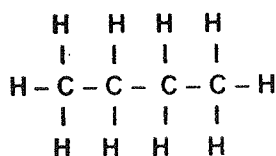
(C) Mass of hydrogen = 58 - 48 = 10 grams

Number of carbon atoms = 48 ÷ 12 = 4 atoms

Number of hydrogen atoms = 10 atoms

The molecular formula of the hydrocarbon C_4H_{10}.

The structural formulas for the two isomers are:

D) 1) 3, 4- diethyl octane.　　2) 4- chloro -1- butene.
　3) 3-methyl -1- pentene.　　4) 4- methyl -1- heptyne.

Answer four only of the following questions

Question (1)

(A) Choose the correct answer:

1. Sulphonation reaction of aromatic benzene ring is ....reaction.

   a- oxidation   b- addition.   c- substitution   d- elimination

2. Dichloro diphenyl trichloro ethane is the chemical name of the ....compound.

   a- Teflon   b- Gamixane   c- D.D.T   d- Aspirin

3. When sodium benzoate is heated with soda lime, the product is ....

   a- benzoic acid.   b- toluene.   c- benzene.   d- benzaldehyde.

4. When benzene is reacted with chlorine in direct sunlight .... is formed.

   a- benzoic acid.   b- toluene.   c- benzene.   d- gamexane

5. Dry distillation of anhydrous sodium benzote with soda lime gives ......

   a- benzoic acid.   b- benzene.   c- toluene.   d- benzaldehyde.

6. The product of halogenations of nitrobenzene is ....

   a- ortho-chloromtrobenzene.   b- para-chloronitrobenzene.

   c- ortho-nitrochlorobenzene.   d- meta-chloronitrobenzene.

B) How can you obtain:

1) Benzene from calcium carbide.
2) Gamixane from phenol.
3) Chlorotoluene from benzene.
4) Nitrobenzene from sodium benzoate.

C) Mention the molecular and structural formulae of:

       1- Naphthaline.   2- Diphenyl.

Do you consider these two compounds isomers? Why?

Question (2)

A) Write the Scientific expression for each of the following:

1. The reaction of benzene with methyl chloride in the presence of a catalyst.
2. Reaction of benzene with alkyl halide (by substitution) to produce toluene.
3. A process of replacement of one hydrogen atom or more in the benzene ring by a nitro group.
4. Important organic compounds obtained by treatment of alkyl benzene sulphonic acid with caustic soda.
5. A process of replacement of one hydrogen atom or more in the benzene ring by a sulphonic group.
6. Saturated cyclic hydrocarbons their general molecular formula is C_nH_{2n}

B) Show by symbolic equations the following reactions referring to the conditions of the reactions:

1. Dry distillation of anhydrous sodium benzoate.
2. Sulphonation of benzene.
3. Coloration of toluene.
4. Coloration of nitrobenzene.

C) Mention the name of scientist who reached to the hexagonal cyclic shape for benzene in which single and double bonds are exchanged.

Question (3)

A) Give reasons for:

1. Normal propane is less active than cyclopropane.
2. When nitrobenzene reacts with chlorine, ortho chloro nitro benzene is not formed.
3. The poly nitro organic compounds are very explosive substances.
4. D.D.T is not used now as insecticide many countries.
5. Although cyclo alkanes and alkenes have the same general formula C_nH_{2n} they are different in the chemical properties.

**B) Explain by symbolic chemical equations what happened in each of the following cases:**

1. Passing acetylene gas in a red hot nickel tube and the reaction of the product with chlorine in direct sunlight.
2. Hydrogenation of benzene in the presence of a catalyst.
3. Obtaining toluene from benzene.
4. Nitration of toluene and benzene.

C) Show by balanced chemical equations the effect of heat on the following substances:

1. Normal hexane in the presence of platinum.
2. Phenol in presence of zinc.

Question (4)

A) What is the number of hydrogen moles necessary to react with one mole of each of the following to obtain saturated compounds:

1.   2. $CH = CH_2$
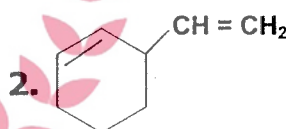
B) How can you obtain:

1) Methyl benzene from sodium benzoate.
2) Detergent from alkyl benzene sulphonic acid.
3) T.N.T from benzene.
4) Cyclohexane from normal hexane.
5) Benzene from phenol.

C) Give reasons for:

1. Nitration of chloro benzene gave two products while chlorination of nitrobenzene gave one product.
2. Cyclohexane is an aliphatic compound, while aromatic benzene is unsaturated compound.
3. D.D.T compound has poisonous effect on insects.
4. The detergents can remove the spots and dirty from clothes
5. Cyclopropane and cyclobutane are very active compounds.

Question (5)

A) What is meant by:

1. Friedel- Craft's reaction.
2. Halogenation of benzene.

B) "It is possible to obtain aromatic benzene in industry from aliphatic petroleum derivatives".

Mention the chemical equations, and the conditions which are required to obtain benzene by two different methods from these derivatives in industry.

C) Mention the name of the organic compound:

1) The ugliest compound in the history of chemistry although it is used as insecticide for long ages.
2) A compound consists of three benzene rings.
3) An explosive compound is produce from nitration of toluene.
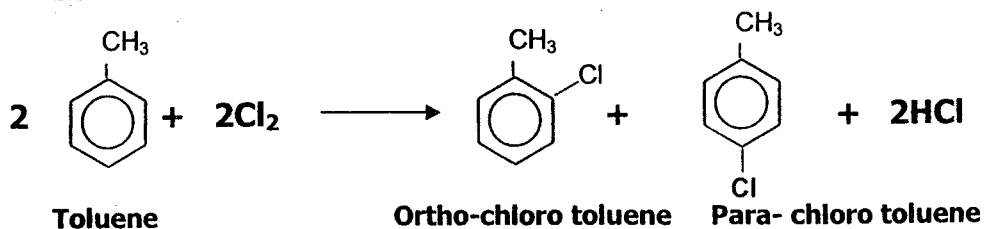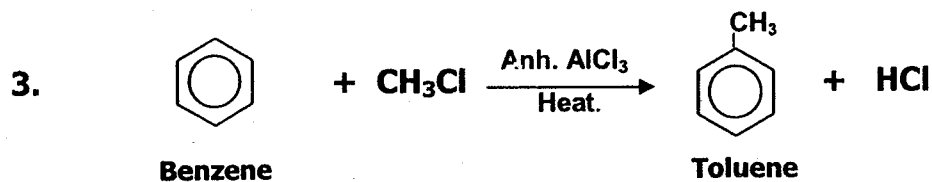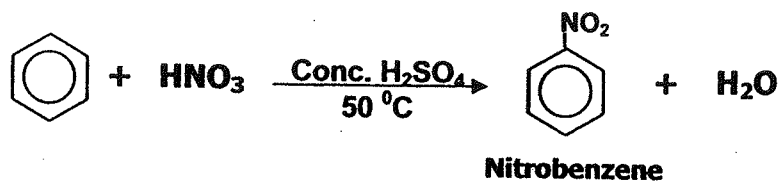
D) Write the chemical name for each of the following:

1.
$H_3C – CH – CH_3$

2.
Cl
NO_2

Br

3.
$CH_3-CH-CH_2-CH-CH_3$
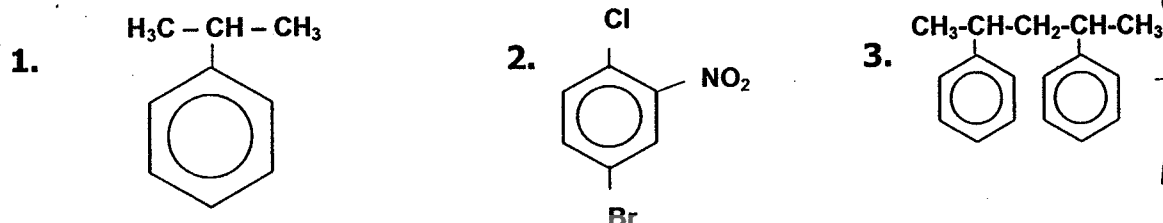
Answer Exam (10) on cyclic hydrocarbons

Answer of question (1)

A)	1	2	3	4	5	6
	c	c	c	d	b	d

B)

1.
$$CaC_2 + 2H_2O \xrightarrow{\text{Dropping}} C_2H_2 + Ca(OH)_2$$

$$3C_2H_2 \xrightarrow{\text{Red hot nickel tube}} C_6H_6$$

2.

OH

Phenol   + Zn $\xrightarrow{\text{Heat}}$ Benzene   + ZnO

+ 3 Cl$_2$ $\xrightarrow{\text{Direct sunlight}}$ $C_6H_6Cl_6$

Benzene hexa chloride (Gamixane)

3.

Benzene   + CH_3Cl $\xrightarrow[\text{Heat.}]{\text{Anh. AlCl}_3}$ Toluene   + HCl

2 Toluene + 2Cl$_2$ $\longrightarrow$ Ortho-chloro toluene   +   Para- chloro toluene   + 2HCl

4.

Sodium benzoate + NaOH $\xrightarrow[\triangle]{CaO}$ Benzene + Na_2CO_3

Benzene + HNO_3 $\xrightarrow[50\ ^{0}C]{Conc.\ H_2SO_4}$ Nitrobenzene + H_2O
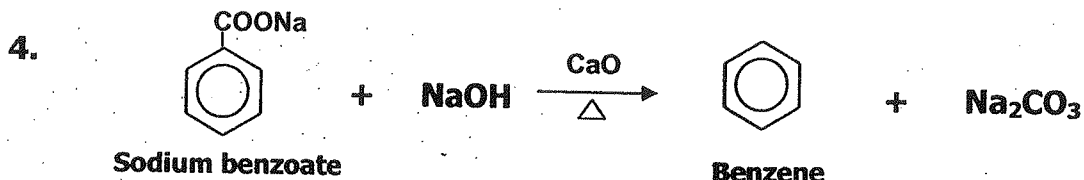
C) 1- Structural formula for naphthalene is

2- Structural formula for diphenyl is
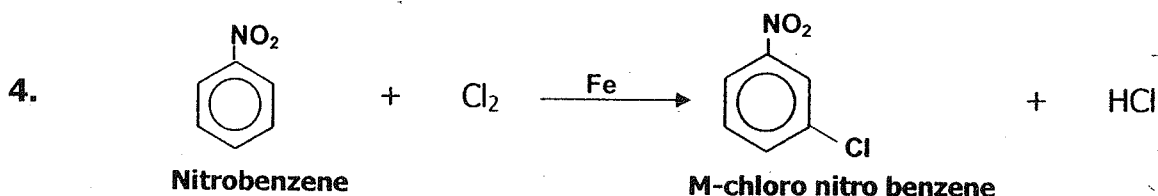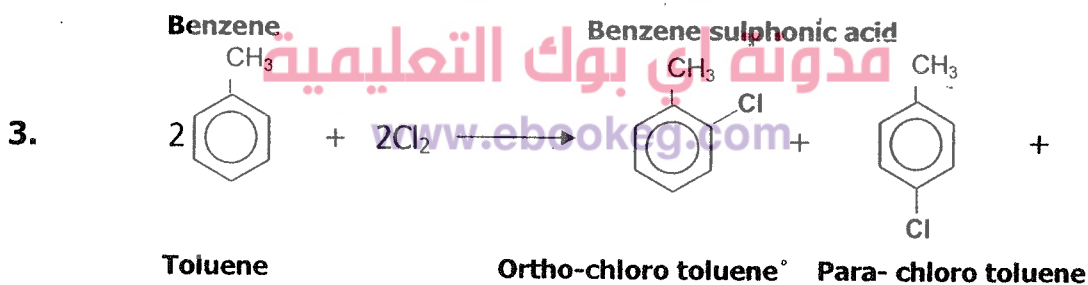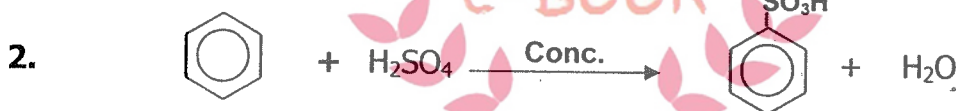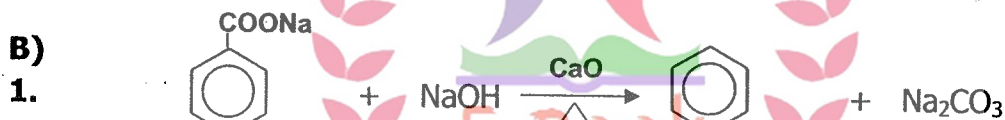
They are not isomers due to different molecular formula for each of them, where ($C_{10}H_8$) naphthalene - $C_{12}H_{10}$ Diphenyl)

Answer of question (2)

A) 1. Friedel craft's reaction. **2.** Friedel craft's reaction. **3.** Nitration.
4. Artificial detergents. **5.** Sulphonation. **6.** Cyclo alkanes

B)

1. Sodium benzoate + NaOH $\xrightarrow[\triangle]{CaO}$ Benzene + Na_2CO_3

2. Benzene + H_2SO_4 $\xrightarrow{Conc.}$ Benzene sulphonic acid + H_2O

3. 2 Toluene + $2Cl_2 \longrightarrow$ Ortho-chloro toluene + Para- chloro toluene + 2HCl

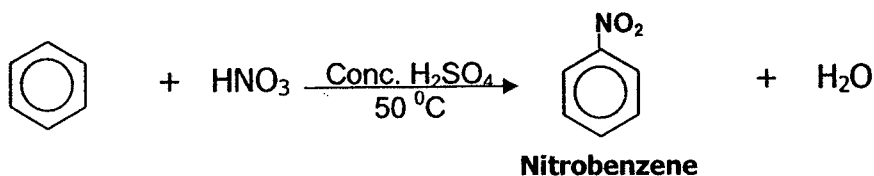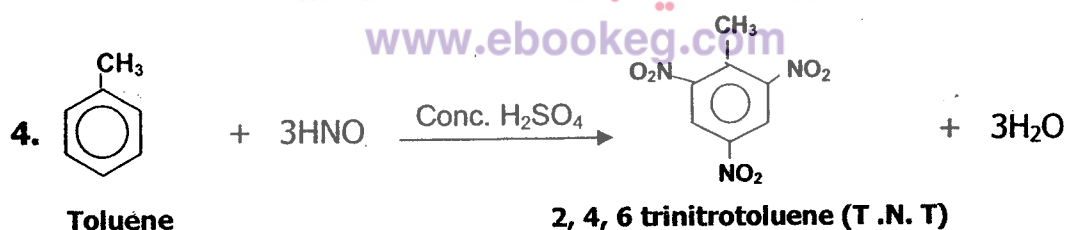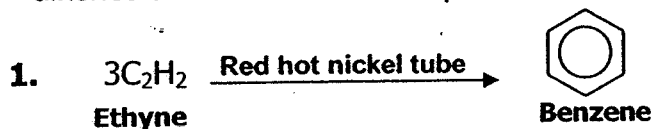**4.** Nitrobenzene + $Cl_2 \xrightarrow{Fe}$ M-chloro nitro benzene + HCl

C) Kekule
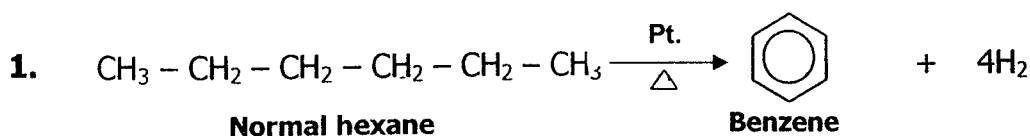
Answer of question (3)

A) 1. This is because the value of angles between bonds in cyclopropane is lower than 109° which leads to weak overlapping between orbitals.

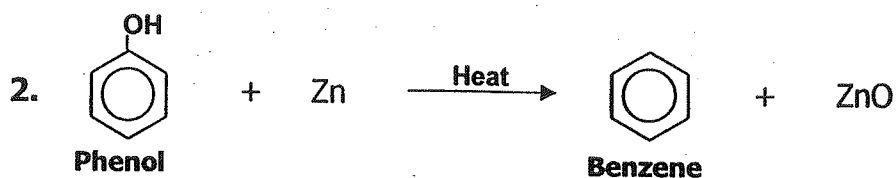2. Because nitro group directs the reaction towards the meta position.

3. Because the poly nitro organic compounds contain their own fuel, which is carbon beside oxygen which is the oxidizing agent. These compounds burn rapidly and a great amount of heat and gases are reduced accompanied by explosion. This is due to the weakness of the bond $(N-O)$ to from the two strong bonds $(C-O)$ in carbon dioxide and the bond $(N-N)$ in nitrogen molecule.

4. Because it remains in the environment without being decayed killing the useful insects as the bees. Besides, it goes with the rains to the rivers and lakes affecting the fish and the aquatic creatures until it reaches the man.

5. Because cyclo alkanes are saturated compounds cannot react by addition, while alkenes are unsaturated compounds can react by addition.

B)

1.

$$3C_2H_2 \xrightarrow{\text{Red hot nickel tube}}$$

Ethyne → Benzene

Then

Benzene $+ 3Cl_2 \xrightarrow{\text{Direct sunlight}}$

Benzene hexa chloride (Gamexane)

2.

Benzene $[C_6H_6]$ $+ 3H_2 \xrightarrow[\text{Catalyst}]{\text{Heat / pressure}}$ Cyclohexane $[C_6H_{12}]$

3.

Benzene $+ CH_3Cl \xrightarrow[\text{Heat.}]{\text{Anh. AlCl}_3}$ Toluene $+ HCl$

4.

Toluene $+ 3HNO \xrightarrow{\text{Conc. H}_2\text{SO}_4}$ 2, 4, 6 trinitrotoluene (T .N. T) $+ 3H_2O$

Benzene $+ HNO_3 \xrightarrow[50\ ^{0}C]{\text{Conc. H}_2\text{SO}_4}$ Nitrobenzene $+ H_2O$

(C)

1.

$$CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3 \xrightarrow[\triangle]{\text{Pt.}}$$ Benzene $+ 4H_2$

Normal hexane → Benzene

2.

Phenol + Zn $\xrightarrow{\text{Heat}}$ Benzene + ZnO

Answer of question (4)

A) 1. Three moles
2. Two moles

B)

1.

+ NaOH $\xrightarrow[\triangle]{\text{CaO}}$ Benzene + Na_2CO_3

Benzene + CH_3Cl $\xrightarrow[\text{Heat.}]{\text{Anh. AlCl}_3}$ Methyl benzene (Toluene) + HCl

2. R—⬡—SO_3H + NaOH $\longrightarrow$ R—⬡—$SO_3^-Na^+$ + H_2O

Alkyl benzene sulphonic acid   **Sodium salt of alkyl benzene**

3.

Benzene + CH_3Cl $\xrightarrow[\text{Heat.}]{\text{Anh. AlCl}_3}$ Methyl benzene (Toluene) + HCl

Toluene + $3HNO_3$ $\xrightarrow{\text{Conc. H}_2\text{SO}_4}$ 2, 4, 6 trinitrotoluene (T.N.T) + $3H_2O$

4. C_6H_{14} $\xrightarrow{\text{Pt}/\Delta}$ $C_6H_6 + 4H_2$

$C_6H_6 + 3H_2$ $\xrightarrow[\text{Catalyst}]{\text{Heat/ pressure}}$ C_6H_{12}

5.

Phenol + Zn $\xrightarrow{\text{Heat}}$ Benzene + ZnO
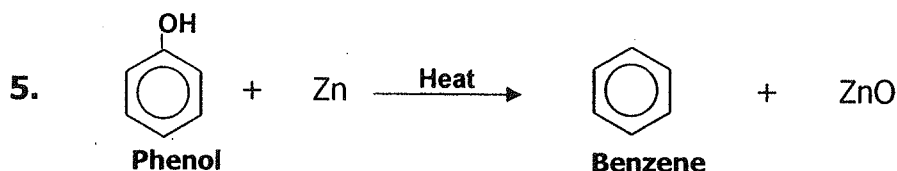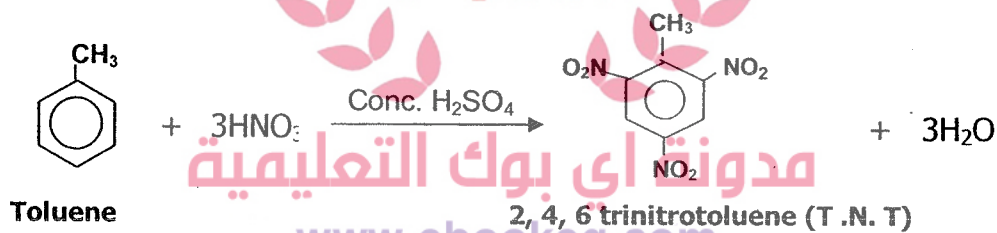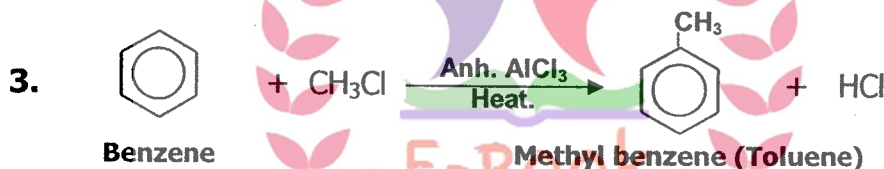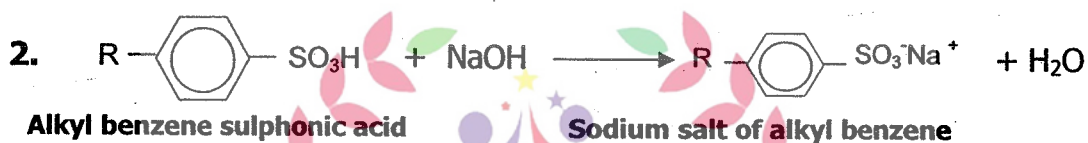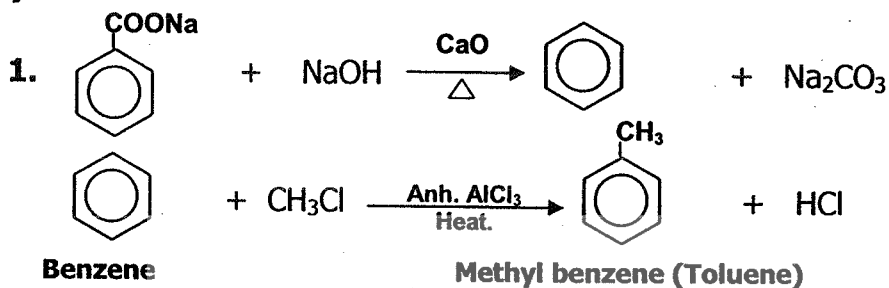
C) 1. Because the halogen atom (chlorine) direct the reaction towards the ortho and para positions, while nitro group directs the reaction towards the Meta position.
2. Because all bonds in cyclohexane are single but aromatic benzene has three double bonds.
3. Because it contains (-$CHCCl_3$) group which dissolves in fat of any insect and kills it.
4. When the detergent is dissolved in water their molecules arrange themselves

where the hydrophobic tail of each molecule is directed towards the dirties and the textile and adhere with them. While the hydrophilic head is directed towards water, so the detergent molecules surround the dirties completely.
- The dirties and textile completely covered by detergent molecule, with any mechanical rubbing the cleaning process starts. Where the like charges repel so the textile and dirties are repelled with each other because both of them are covered with the heads of the molecules which carry a positive electric charges.

5. Because the angles between the bonds in them are less than 109°, and these small angles lead to weak overlap between the atomic orbitals. Therefore, the combination between carbon atoms is very weak.

Answer of question (5)

A) 1. Friedel craft's reaction: Reaction of benzene with alkyl halides in the presence of anhydrous aluminum chloride.

Example:

Benzene + CH_3Cl $\xrightarrow[\text{Heat}]{\text{Anh. } AlCl_3}$ Toluene (Methyl benzene) + HCl
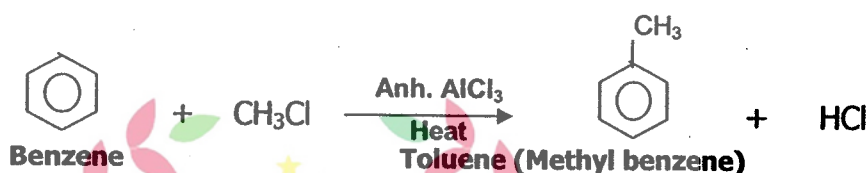
2. Halogenation of benzene: is the replacement one hydrogen atom or more of benzene ring by one halogen atom or more.

Example: reaction of chlorine with benzene.

Benzene + Cl_2 $\xrightarrow[\text{I.S.L}]{FeCl_3}$ Chlorobenzene + HCl
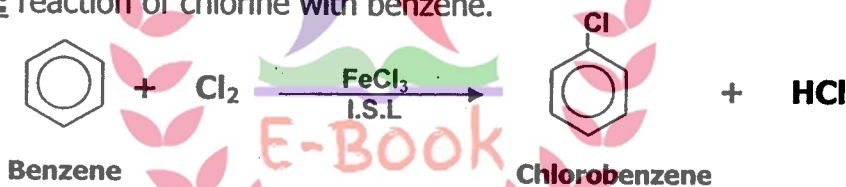
B) - From normal hexane (catalytic reforming method):

Normal hexane is passed at high temperature on the surface of platinum as a catalyst.

$$CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3 \xrightarrow[\triangle]{Pt.} \text{Benzene} + 4H_2$$

Normal hexane → Benzene
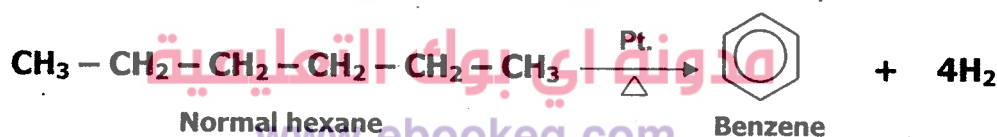
- Polymerization of ethyne :

By passing ethyne vapour in a red hot nickel tube.

$$3C_2H_2 \xrightarrow{\text{Red hot nickel tube}} \text{Benzene}$$

Ethyne → Benzene
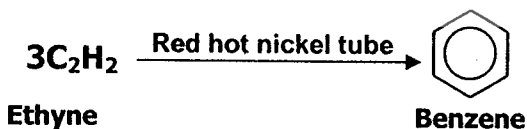
C) 1. Dichloro diphenyl, trichloro ethane (D.D.T).
   2. Anthracene.
   3. 2, 4, 6 trinitrotoluene (T.N.T).

D) 1) 2- Phenyl propane.
   2) 4- Bromo - 1- chloro - 2 - nitro benzene.
   3) 2,4-diphenyl pentane.

Exam (11) based on Hydrocarbons

Answer four only of the following questions

Question (1)

A) Choose the correct answer:

1. The number of carbon atoms in alkane having 14 hydrogen atoms is......
   - a) 14
   - b) 7
   - c) 6
   - d) 5

2. Saturated cyclic hydrocarbons which composed ......
   - a) alkanes.
   - b) cycloalkanes.
   - c) alkynes.
   - d) aromatic compounds.

3. The most active compound from these compounds is ......
   - a) CH_4
   - b) C_4H_8
   - c) C_4H_{10}
   - d) C_3H_4

4. The most active compound from these compounds is ......
   - a) cyclopropane.
   - b) normal propane.
   - c) cyclopentane.
   - d) cyclohexane.

5. Formation of polyethylene is considered from ...... polymerization
   - a) condensation
   - b) addition
   - c) substitution
   - d) elimination.

6. Nitration of chloro benzene gives ......
   - a) meta - chloro nitrobenzene.
   - b) ortho - chloro nitrobenzene.
   - c) para - chloro nitrobenzene.
   - d) mixture of (b) and (c).

B) Write chemical equations that illustrate each of the following :

1. Conversion of a normal alkane to cyclo alkane.
2. Obtaining acetaldehyde from calcium carbide.
3. Conversion of ethanol to methane.
4. Conversion of phenol to gamexane.

C) How can you identify the presence of carbon and hydrogen in organic compound (write balanced equation)?

D) Identify the following organic compounds then write their molecular and structural formulae and write their IUPAC names.

1. Two organic compounds obtained from thermal catalytic cracking of octane.
2. A compound obtained from heating ammonium cyanate.
3. The compound that reacts with potassium permanganate solution in an alkaline medium and gives a substance used as antifreeze material.

Question (2)

A) Explain how ethene (ethylene) gas is prepared in laboratory? Draw the apparatus used and write the balanced chemical equation.

B) How can you differentiate between :

1. Methane and ethene.
2. Methane and ethyne.

C) Write a scientific expression for each of the following statements:

1. Addition of water to alkenes or alkynes in the presence of a catalyst.
2. Easy liquefied halogenated alkanes used in manufacture of cooling systems.
3. Reaction of benzene with alkyl halides in the presence of anhydrous aluminum chloride.
4. Combination of two monomers to form copolymer and losing a small molecule such as water.
5. Conversion of long chain hydrocarbons to a shorter one by the effect of heat,

pressure and catalyst.

6. The presence of more than one organic compound having the same molecular formula
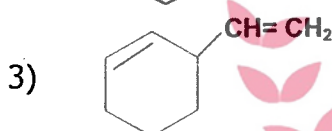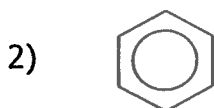
Question (3)

A) Give a scientific explanation for each of the following :

1. The failure of vital force theory by Wohler.
2. Alkenes and alkynes are more active than alkanes.
3. Ethylene glycol is used as an antifreeze material in car radiators.
4. Halothane is preferred than chloroform as anesthetic substance.

B) Write molecular and structural formula for each of the following :

1. A saturated cyclic hydrocarbon obtained on hydrogenation of benzene.
2. An unsaturated aliphatic hydrocarbon produced from thermal decomposition of ethyl hydrogen sulphate at 180 °C
3. An unsaturated aliphatic hydrocarbon having a triple bond and three carbon atoms.

C) What is the number of hydrogen moles required to react with one mole of the following compounds to obtain saturated compounds?

1) $CH_3 - CH = CH - CH = CH - CH_3$

2)

3)

Question (4)

A) What are the starting materials or chemicals required to prepare each of the following:
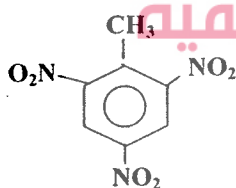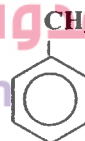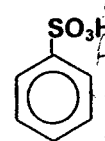
(a) (b) (c) (d)

B) How is benzene prepared from sodium benzoate? Write the chemical equation of the reaction.

C) How can you obtain:

1. 2, 4, 6 trinitro toluene (T. N. T) from calcium carbide.
2. Ethanoic acid from calcium carbide.
3. Ethylene glycol from ethanol.
4. Chloroform from methane.
5. Water gas from sodium acetate.

D) Bromine solution dissolved in CCl_4 is not suitable to differentiate between ethylene and acetylene.

Question (5)

A) Draw the structural formula of the monomer required to prepare the following polymers.
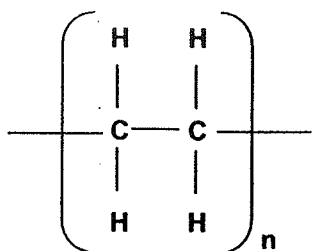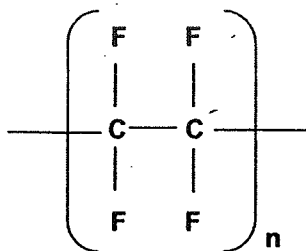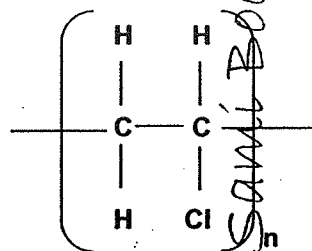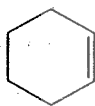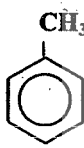
(1) (2) (3)

B) How is acetylene gas prepared in the laboratory? Draw the apparatus used. And write the equation of the reaction.

C)

a)	b) $CH_2 = CH_2$	c) $CH_3CH = CH_2$
d) CH_3	e)	f) $H - C \equiv C - H$

Choose from the above table the compound (or compounds) which:

1. Reacts with two moles of bromine giving a tetrabromo compound.
2. Its catalytic hydration gives an aldehyde.
3. Used to prepare an explosive compound.
4. Reacts by addition and substitution.
5. Add one mole of hydrogen and converted to cycloalkanes.
6. Reacts with hydrogen bromide and addition obeys Markonikoff's rule.

D) Methane, and acetylene are aliphatic hydrocarbons, whereas benzene is considered an aromatic one.

a) Why each of acetylene and benzene sometimes burns with smoky flame?

b) Explain how to prepare methane in laboratory, Draw the used apparatus then show what is the effect of each of the following on methane.

1. Halogens at 400 °C.
2. Heating to 1000 °C (Mention one use for the product).
3. Water vapour (mention the use of the product).

Answers Exam (11) of Hydrocarbons

Answer of Question (1)

A) 1	2	3	4	5	6
C	b	d	a	b	d

B) 1. $C_6H_{14} \xrightarrow{Pt/\Delta} C_6H_6 + 4H_2$

$C_6H_6 + 3H_2 \xrightarrow[\text{Catalyst}]{\text{Heat/ pressure}} C_6H_{12}$

2. $CaC_2 + 2H_2O \xrightarrow{\text{dropping}} C_2H_2 + Ca(OH)_2$

Then $C_2H_2 + H_2O \xrightarrow[\text{HgSO}_4 / 60^0C]{H_2SO_4\ 40\%} CH_3CHO$

3. $C_2H_5OH \xrightarrow[180^0C]{\text{Conc.H}_2SO_4} C_2H_4 + H_2O$

$C_2H_4 + H_2 \xrightarrow{Ni/\Delta} C_2H_6$

4. $C_6H_5OH + Zn \xrightarrow{\Delta} C_6H_6 + ZnO$

$C_6H_6 + 3Cl_2 \xrightarrow{D.S.L} C_6H_6Cl_6$ (Gamexane)
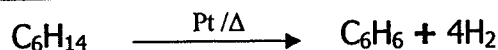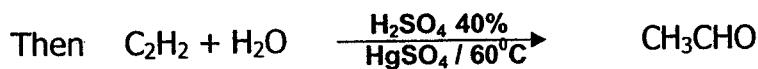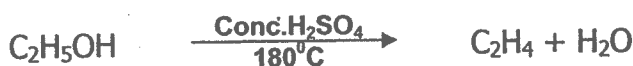
C) Test for carbon and hydrogen in organic compounds:
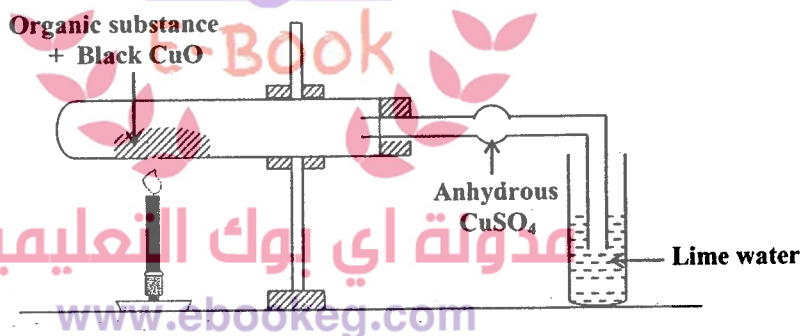
Experiment:
  1- Heat the organic substance with copper oxide [CuO].
  2- Pass the resulting gases over white copper sulphate, then through lime water.

Observation:
 - The white copper sulphate turns blue.
 - The lime water becomes milky.

Conclusion:
The organic substance contains:-
 - Carbon which is oxidized to carbon dioxide makes lime water milky.
 - Hydrogen which is oxidized to water changes the white cu so4 into blue Cu SO4.

$C + 2CuO \xrightarrow{\Delta} CO_2 + 2Cu$

$2H + CuO \xrightarrow{\Delta} H_2O + Cu$
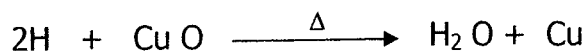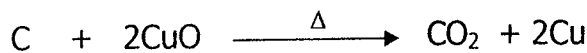
D) 1. Two organic compounds obtained from thermal catalytic cracking of octane:
   The two organic compounds are butane and butene.

The molecular formula of butane is C_4H_{10}
The structural formula of butane is:
The IUPAC name of butane is butane

$$H - \overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}} - \overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}} - \overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}} - \overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}} - H$$
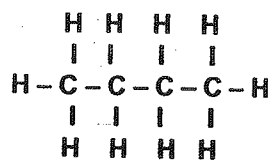
The molecular formula of butene is C_4H_8
The structural formula of butene is:
The IUPAC name of butene is 1- butene

$$H - \overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}} - \overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}} - \overset{\overset{\displaystyle H}{|}}{C} = \overset{\overset{\displaystyle H}{|}}{C} - H$$
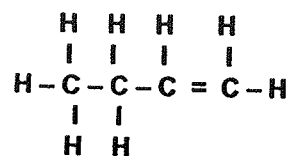
2. A compound obtained from heating ammonium cyanate.

The compound is Urea

The molecular formula is $H_2N - CO - NH_2$

The structural formula is

$$H - \overset{\overset{\displaystyle H}{|}}{N} - \overset{\overset{\displaystyle O}{||}}{C} - \overset{\overset{\displaystyle H}{|}}{N} - H$$

3. The compound that reacts with potassium permanganate solution in an alkaline medium and gives a substance used as antifreeze material.

The compound is ethene (ethylene)

The molecular formula is C_2H_4

The structural formula is

$$H - \overset{\overset{\displaystyle H}{|}}{C} = \overset{\overset{\displaystyle H}{|}}{C} - H$$
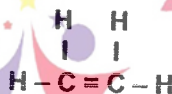
Answer of Question (2)

A) Preparation of ethene in laboratory:

The equation of reaction:

$$C_2H_5OH \xrightarrow[180\,^{\circ}C]{Conc.H_2SO_4} C_2H_4$$
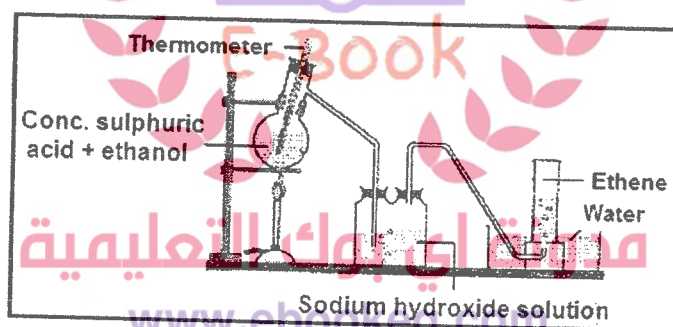
B) 1. Differentiation between methane and ethane:

Experiment	Methane gas	Ethene (ethylene) gas
By adding bromine dissolved in (CCl_4) to each of them.	No effect	The red colour of bromine is removed
By adding potassium permanganate solution in an alkaline medium to each of them	No effect	The violet colour of potassium permanganate is removed

2. Differentiation between methane and ethyne:

Experiment	Methane gas	Ethyne (acetylene) gas
By adding bromine dissolved in (CCl_4) to each of them.	No effect	The red colour of bromine is removed

C) 1. Catalytic hydration.   2. Freons.

3. Alkylation (Friedle craft's reaction).   4. Condensation polymerization.

5. Thermal catalytic cracking.   6. Isomerism.

Answer of Question (3)

A) 1. This is because Wohler prepared urea by heating an aqueous solution of two inorganic compounds, ammonium chloride and silver cyanate in laboratory.

$$NH_4Cl + AgCNO \xrightarrow{\Delta} AgCl + NH_4CNO$$

$$NH_4CNO \xrightarrow{\Delta} H_2N\text{-}CO\text{-}NH_2$$
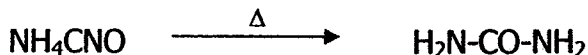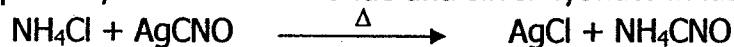
2. Because alkenes have two bonds between the two carbon atoms one of them is weak pi bond which can be broken easily and alkynes have three bonds between the two carbon atoms two of them are weak pi bonds which can be broken easily but all bonds in alkanes of strong sigma type that cannot be broken easily.

3. This is because ethylene glycol forms hydrogen bonds with water molecules and prevents their combination with each other in the form of ice crystals.

4. This is because the inaccurate dose of chloroform causes death.

B) 1. The molecular formula C_6H_{12}, The structural formula

2. The molecular formula C_2H_4, The structural formula

$$H - C = C - H$$ (with H atoms on each carbon)
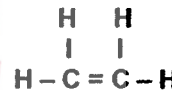
3. The molecular formula C_3H_4, The structural formula

$$H - C - C \equiv C - H$$ (with H atoms on first carbon)
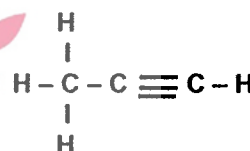
C) 1. Two moles.

2. Three moles.

3. Two moles.

Answer of Question (4)

A) a) The starting materials are: toluene, conc. Nitric acid and conc. Sulphuric acid.

b) The starting materials are: benzene, chlorine, and iron three chloride ($FeCl_3$).

c) The starting materials are: benzene, methyl chloride and anhydrous aluminum chloride ($AlCl_3$).

d) The starting materials are: benzene, and conc. Sulphuric acid.

B) Preparation of benzene:

$$C_6H_5COONa + NaOH \xrightarrow[\Delta]{CaO} C_6H_6 + Na_2CO_3$$

C) 1.

$$CaC_2 + 2H_2O \xrightarrow{dropping} C_2H_2 + Ca(OH)_2$$

$$3C_2H_2 \xrightarrow{\text{Red hot nickel tube}} C_6H_6$$

$$C_6H_6 + CH_3Cl \xrightarrow[\Delta]{\text{Anh. } AlCl_3} C_6H_6CH_3 + HCl$$

1.
$$\text{(CH}_3\text{-C}_6\text{H}_5) + 3HNO_3 \xrightarrow{\text{Conc.H}_2\text{SO}_4} \text{(CH}_3\text{-C}_6\text{H}_2(\text{NO}_2)_3) + 3H_2O$$

2.
$$CaC_2 + 2H_2O \xrightarrow{\text{dropping}} C_2H_2 + Ca(OH)_2$$

$$C_2H_2 + H_2O \xrightarrow[\text{HgSO}_4 / 60^0\text{C}]{\text{H}_2\text{SO}_4 \ 40\%} CH_3CHO$$

$$CH_3CHO + [O] \xrightarrow[\text{Conc. H}_2\text{SO}_4]{\text{KMnO}_4} CH_3COOH$$

3.
$$C_2H_5OH \xrightarrow[180^0\text{C}]{\text{Conc. H}_2\text{SO}_4} C_2H_4 + H_2O$$

$$C_2H_4 + H_2O + [O] \xrightarrow[\text{Alkaline medium}]{\text{KMnO}_4} C_2H_4(OH)_2$$

4.
$$CH_4 + Cl_2 \xrightarrow{\text{UV or 400 }^\circ\text{C}} CH_3Cl + HCl$$

$$CH_3Cl + Cl_2 \xrightarrow{\text{UV or 400 }^\circ\text{C}} CH_2Cl_2 + HCl$$

$$CH_2Cl_2 + Cl_2 \xrightarrow{\text{UV or 400 }^\circ\text{C}} CHCl_3 + HCl$$

5.
$$CH_3COONa + NaOH \xrightarrow[\text{Heat}]{\text{CaO}} CH_4 + Na_2CO_3$$

$$CH_4 + H_2O \xrightarrow[\text{Catalyst}]{725 ^0\text{C}} CO + 3H_2$$

D) Bromine solution dissolved in CCl_4 is not suitable to differentiate between ethylene and acetylene because it reacts with each of them and removes their colours.

Answer of Question (5)

A)

1.
```
   H   H
   |   |
   C = C
   |   |
   H   H
```

2.
```
   F   F
   |   |
   C = C
   |   |
   F   F
```

3.
```
   H   H
   |   |
   C = C
   |   |
   H   Cl
```

B) Preparation of acetylene in lab.

$$CaC_2 + 2H_2O \xrightarrow{\text{dropping}} C_2H_2 + Ca(OH)_2$$
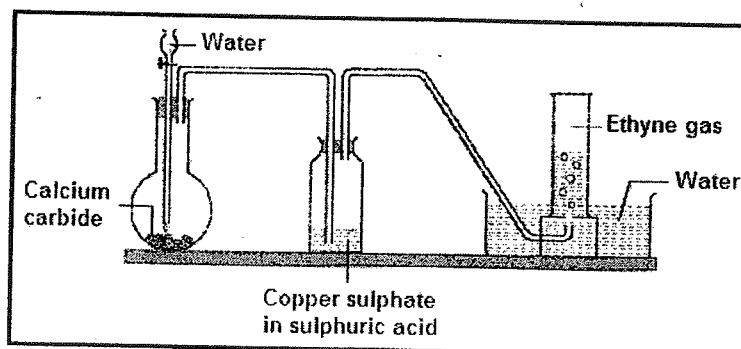
C) (1) with (f)   (2) with (f)   (3) with (d)
    (4) with (e)   (5) with (a)   (6) with (c).

D) a) Each of acetylene and benzene sometimes burns with smoky flame when the amount of oxygen is limited and carbon in each of them does not completely burnt.

b) Preparation of methane in laboratory:

$$C_2H_5COONa + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$
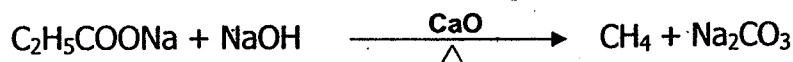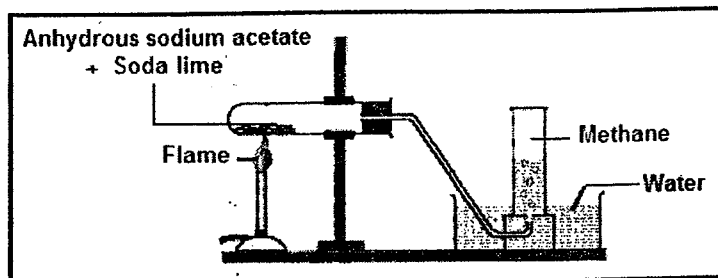
1. Reaction of methane with halogen at 400 °C:

$$CH_4(g) + Cl_2(g) \xrightarrow{UV\ or\ 400\ ^\circ C} CH_3Cl(g) + HCl(g)$$
Methyl chloride

$$CH_3Cl(g) + Cl_2(g) \xrightarrow{UV\ or\ 400\ ^\circ C} CH_2Cl_2(g) + HCl(g)$$
Dichloro methane

$$CH_2Cl_2(g) + Cl_2(g) \xrightarrow{UV\ or\ 400\ ^\circ C} CHCl_3(g) + HCl(g)$$
Trichloro methane
(Chloroform)

$$CHCl_3(g) + Cl_2(g) \xrightarrow{UV\ or\ 400\ ^\circ C} CCl_4(\ell) + HCl(g)$$
Tetrachloro methane
(Carbon tetrachloride)
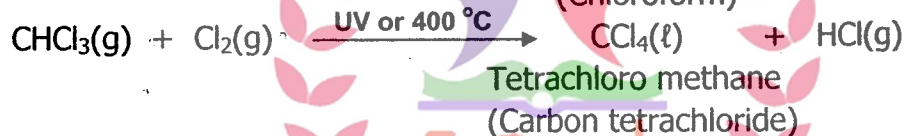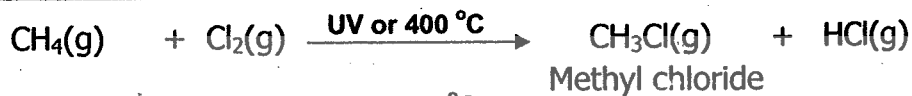
2. Heating methane to 1000 °C:

$$CH_4 \xrightarrow[\text{In absence of air}]{1000\ ^\circ C} C + 2H_2$$
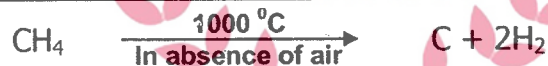
The black carbon is used in the manufacture of (printing ink – car tires – polishes).

3. Reaction of methane with water vapour:

$$CH_4 + H_2O \xrightarrow[\text{Catalyst}]{725\ ^\circ C} CO + 3H_2$$

Water gas (CO + 3H₂) is used as a reducing agent in the Midrex furnace.

Exam (12) on alcohols and phenols

Answer four only of the following questions

Question (1)

A) Choose the correct answer:

1. Addition of drops of iron (III) Chloride solution to the phenolic water solution gives ....

   a- violet colour.   b- brown colour.   c- yellow colour.   d- orange colour.

2. Hydrolysis of sucrose gives...............

   a- lactose and maltose.   b- glucose and galactose.

   c- glucose and fructose.   d- fructose and galactose.

3. (1- propanol) is considered from .... alcohol.

   a- secondary monohydric.   b- primary monohydric.

   c- primary dihydric.   d- tertiary monohydric.

4. The carbinol is attached to one carbon atom and two hydrogen atoms in .... Alcohol.

   a- primary.   b- secondary.   c- tertiary.   d- dihydric.

5. Isopropyl alcohol (2-propanol) is ....alcohol.

   a- primary.   b- secondary.   c- dihydric.   d- tertiary.

6. 1,2,3- trihydroxy benzene is known as ....

   a- carbolic acid   b- phenol   c- catechol   d- pyrogallol.

B) Compare between each pair of the following:

1) Acidic property of alcohols and acidity of phenols.

2) Reaction of sodium with each of ethanol and phenol.

C) Show by symbolic equations how you can obtain:

1) Ethylene glycol from ethanol.   **2)** Diethyl ether from ethylene.

3) Picric acid from sodium benzoate.   **4)** Acetone from 2- bromopropane.

Question (2)

A) Write the Scientific expression for each of the following:

1) The reaction of alcohols with carboxylic acids in the presence of a dehydrating agent.

2) Alcohols in which the carbinol group doesn't carry any hydrogen atoms.

3) Polyhydroxy aldehydes or polyhydroxy ketones.

4) Organic compounds having ($-CH_2OH$) group in their structures.

5) Aromatic organic compounds having two hydroxyl groups attached directly to the benzene ring.

B) A and B are two organic compounds having the molecular formula [C_2H_6O].

1. Write the structural formula for each compound.

2. If compound (A) responds to oxidation reactions and compound (B) does not. How can you convert compound (A) to a compound that has the function group of compound (B)?

3. How can you obtain hydrogen from one of the two compounds?

C) 1. Write the chemical equation that illustrates the hydrolysis of sodium ethoxide, and then explain how you can get ethyl chloride from the product.

2. Explain by symbolic chemical equations what happened in each of the following cases.
   a. The reaction of ethanol with concentrated sulphuric acid at 180 °C.
   b. A mixture of ethyl alcohol and concentrated sulphuric acid is heated at 140 °C.

Question (3)

A) Give reasons for:
1) Ethanol can be considered as petrochemical compound.
2) Caustic soda reacts with phenol and not reacted with ethanol.
3) Secondary alcohols are easily oxidized whereas tertiary alcohols are not oxidized.
4) It is impossible to eliminate the hydroxyl group from phenol when it reacts with acids.
5) Iron III chloride is used to differentiate between carbolic acid and ethanol.

B) Arrange the following organic compounds in ascending order according to their boiling points, give the scientific reason:

Sorbitol - Ethylene glycol - Glycerol - Ethanol

C) Show by symbolic equations how you can obtain:
1) Secondary alcohol from propene.
2) Picric acid from acetylene gas.
3) Ethanoic acid from ethene.
4) Phenol from benzene and vice versa.

Question (4)

A)

2-propanol	1-propanol	Picric acid
2-methyl -1-propanol	2-methyl -2-propanol	Catechol

Choose from the above table, the compound (or compounds) that considered:
1- A Phenol.
2- A Secondary alcohol.
3- Alcohol which gives aldehyde on oxidation.
4- Alcohol which gives ketone on oxidation.
5- Product of nitration of phenol.
6- Disubstituted benzene.
7- Tetra substituted benzene.

B) How can you differentiate between:
1. Ethanol and 2-methyl-2-butanol
2. Secondary alcohol and tertiary alcohol
3. Ethanol and phenol.

C) Read the following statement, and then answer the questions that follow it:
"When glycerol reacts with substance (X) in the presence of concentrated sulphuric acid, substance (Y) is produced. Substance (Y) is used to widen arteries in the treatment of heart crisis."
1. What is the name of this reaction?
2. Mention another use for substance (Y).
3. Write the balanced chemical equation which describes the reaction of substance (X) with phenol in the presence of concentrated sulphuric acid.

4. What is the type of chemical bonds formed between the atoms in the glycerol molecule?

D) "Ethanol is used in many industries such as converted alcohol, perfumes and alcoholic liquors"

   a) What are the additives provided to ethanol to become a converted alcohol? And why they are added?

   b) Illustrate how to detect the taking of drivers for liquors.

Question (5)

A) Write the balanced chemical equations which illustrate the following:

1. Heating chlorobenzene with sodium hydroxide under high pressure and temperature and then nitrating the produced organic compound.

2. Hydrolysis of ethyl iodide in alkaline medium and then reacting the produced organic compound with concentrated hydrochloric acid in the presence of ($ZnCl_2$).

B) 1. Explain by chemical symbolic equations the role of:

   a. Concentrated sulphuric acid during ester formation.

   b. Zymase enzyme in the production of alcohol in industry.

2. Write one use of:

   a. Ethanol.   b. Ethylene glycol.   c. Glycerol

   d. picric acid   e. Bakelite

C) 1. Classify the corresponding alcohol regarding to the type of carbinol group. Explain your answer.

$$\begin{array}{ccccc} H & H & H & OH & H \\ | & | & | & | & | \\ H-C-C-C-C-C-H \\ | & | & | & | & | \\ H & H & H & CH_3 & H \end{array}$$
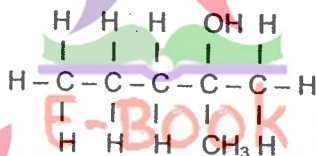
2. Write the structural and molecular formula for the ester which is produced from the following reaction:

$$CH_3CH_2COOH + CH_3OH \xrightarrow{\text{Conc. } H_2SO_4} \text{................}$$

D) Write the structural formula of each of the following compounds, then correct their names.

1) 2 - ethyl -1- propanol.

2) 2 - Methyl - 3- butanol.

3) 3 - Ethyl -2- butanol.

4) 1, 1 - dimethyl -1- butanol.

Answer of question (1)

A) 1	2	3	4	5	6
a	c	c	a	b	d

B) 1. Acidity of alcohol	Acidity of phenol
1. Alcohols are less acidic than phenols because the alkyl group decreases the length of bond between oxygen and hydrogen atom in (O-H) group and this makes the separation of H^+ ions is more difficult.	1. Phenols are more acidic than alcohols because the aryl group increases the length of bond between oxygen and hydrogen atom in (O-H) group and this makes the separation of H^+ ions is easier.
2. Alcohols react with active metals such as sodium but do not react with NaOH.	2. Alcohols react with active metals such as sodium and react with NaOH.

2) - Reaction of sodium with ethanol.

$$2\ C_2H_5OH + 2Na \longrightarrow 2C_2H_5ONa + H_2 \text{ (burns with a pop sound)}$$
(Sodium ethoxide)

- Reaction of sodium with phenol.
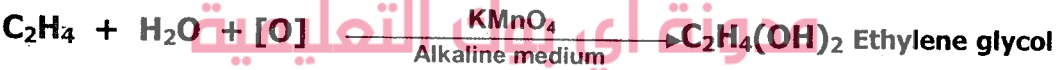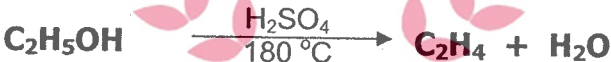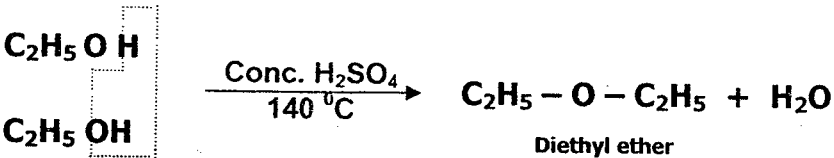
Phenol   **Sodium phenoxide**

C) 1) Ethylene glycol from ethanol.

$$C_2H_5OH \xrightarrow[180\,^\circ C]{H_2SO_4} C_2H_4 + H_2O$$

$$C_2H_4 + H_2O + [O] \xrightarrow[\text{Alkaline medium}]{KMnO_4} C_2H_4(OH)_2 \text{ Ethylene glycol}$$

2) Diethyl ether from ethylene.

$$C_2H_4 + H_2O \xrightarrow{H_2SO_4} C_2H_5OH$$

$$\begin{array}{c} C_2H_5\ O\ H \\ C_2H_5\ OH \end{array} \xrightarrow[140\,^0C]{Conc.\ H_2SO_4} C_2H_5 - O - C_2H_5 + H_2O$$
Diethyl ether

3) Picric acid from sodium benzoate.

Sodium benzoate   + NaOH $\xrightarrow[\triangle]{CaO}$ **Benzene**   + Na_2CO_3

$$\text{C}_6\text{H}_6 + \text{Cl}_2 \xrightarrow[\text{I.S.L}]{\text{FeCl}_3} \text{C}_6\text{H}_5\text{Cl} + \text{HCl}$$

$$\text{C}_6\text{H}_5\text{Cl} + \text{Na} \xrightarrow[\text{300 Atmospheres}]{\text{300 °C}} \text{C}_6\text{H}_5\text{OH} + \text{NaCl}$$

$$\text{C}_6\text{H}_5\text{OH} + 3\text{HN} \xrightarrow{\text{Conc. H}_2\text{SO}_4} \text{(Picric acid)} + 3\text{H}_2\text{O}$$

4) Acetone from 2- bromopropane.

$$\underset{\text{2- Bromo propane}}{\text{CH}_3 - \underset{\text{CH}_3}{\overset{\text{H}}{\text{C}}} - \text{Br}} + \text{KOH} \xrightarrow[\triangle]{\text{Aq.}} \underset{\text{2- Propanol (sec. alcohol)}}{\text{CH}_3 - \underset{\text{CH}_3}{\overset{\text{H}}{\text{C}}} - \text{OH}} + \text{KBr}$$

$$\underset{\text{2- Propanol (sec. alcohol)}}{\overset{\text{CH}_3}{\underset{\text{CH}_3}{>}}\text{CHOH}} + [\text{O}] \xrightarrow[\text{Conc. H}_2\text{SO}_4]{\text{KMnO}_4} \underset{\text{Acetone (Propanone)}}{\overset{\text{CH}_3}{\underset{\text{CH}_3}{>}}\text{C} = \text{O}} + \text{H}_2\text{O}$$

Answer of question (2)

A) 1. Ester formation (estrification).   **2.** Tertiary alcohol.
3. Carbohydrates.   **4.** Primary alcohol.
5. Dibasic acids.

B) 1-

2-

$$\underset{\text{C}_2\text{H}_5\text{O}\,\text{H}}{\text{C}_2\text{H}_5\text{O}\,\text{H}} \xrightarrow[140\,^{\circ}\text{C}]{\text{Conc. H}_2\text{SO}_4} \underset{\text{Diethyl ether}}{\text{C}_2\text{H}_5 - \text{O} - \text{C}_2\text{H}_5} + \text{H}_2\text{O}$$

3-

$$2\,\text{C}_2\text{H}_5\text{OH} + 2\text{Na} \longrightarrow \underset{\text{(Sodium ethoxide)}}{2\text{C}_2\text{H}_5\text{ONa}} + \text{H}_2$$

C)

1.

$$\underset{\text{(Sodium ethoxide)}}{2\,\text{C}_2\text{H}_5\text{ONa}} + \text{H}_2\text{O} \longrightarrow \underset{\text{(Ethanol)}}{2\text{C}_2\text{H}_5\text{OH}} + \text{NaOH}$$

$$\text{C}_2\text{H}_5\text{OH} + \text{HCl} \xrightarrow{\text{ZnCl}_2} \underset{\text{(Ethyl chloride)}}{\text{C}_2\text{H}_5\text{Cl}} + \text{H}_2\text{O}$$

2. a.

$$C_2H_5OH \xrightarrow[180\,^\circ C]{Conc.\ H_2SO_4} C_2H_4 + H_2O$$

b.

$$\left.\begin{array}{l} C_2H_5 O \fbox{H} \\ \\ C_2H_5 \fbox{OH} \end{array}\right\} \xrightarrow[140\,^\circ C]{Conc.\ H_2SO_4} C_2H_5 - O - C_2H_5 + H_2O$$

Diethyl ether
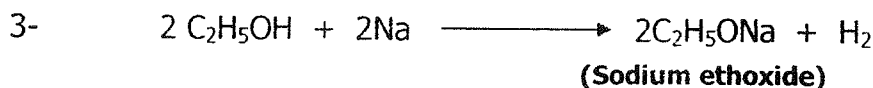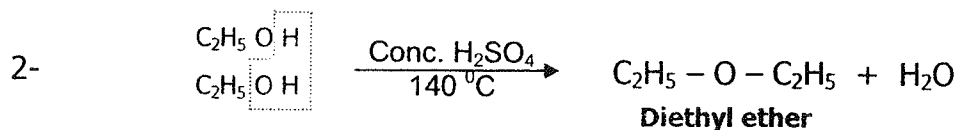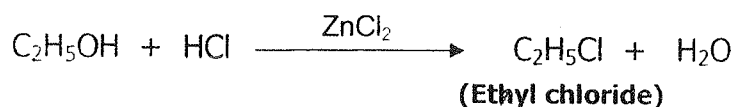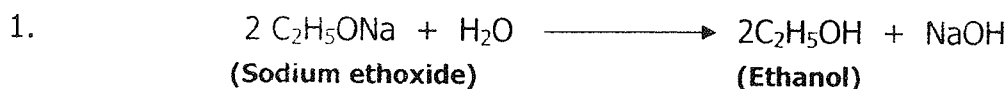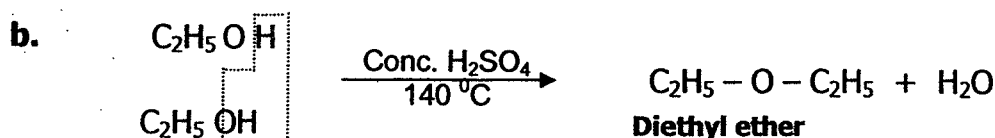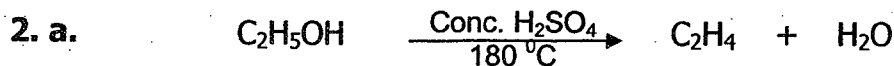
Answer of question (3)

A) 1. Because it is obtained from ethene gas which is produced by thermal cracking of long chain petroleum materials.

2. Ethanol does not react with sodium hydroxide due to the presence of alkyl group which decrease the length of [O-H] bond and becomes difficult to separate of [H⁺], while phenol reacts with sodium hydroxide due to presence of benzene ring which increase the length of [O-H] bond and this facilitates the separation of [H⁺].

3. Because carbinol group of secondary alcohol is attached to one hydrogen atom but carbinol group of tertiary alcohol is not attached to any hydrogen atoms.

4. Because it reacts with carbolic acid giving a violet colour but has no effect with ethanol.

5. Due to the strong bond between the ring and oxygen.

B) Ethanol < ethylene glycol < glycerol < sorbitol

Due to increase of the number of polar hydroxyl groups which have the ability to form hydrogen bonds between the molecules of alcohols causing increase of its boiling point.

C)

1.

$$CH_3 - CH = CH_2 + H_2O \xrightarrow{H_2SO_4} \begin{array}{c} CH_3 - CH - CH_3 \\ | \\ OH \end{array}$$

Propene

2- Propanol (sec. alcohol)

2.

$$3C_2H_2 \xrightarrow{Red\ hot\ nickel\ tube} C_6H_6$$

$$\bigcirc + Cl_2 \xrightarrow[I.S.L]{FeCl_3} \bigcirc\!\!-Cl + HCl$$

$$\bigcirc\!\!-Cl + N\overset{\circ}{a} \xrightarrow[300\ Atmospheres]{300\,^\circ C} \bigcirc\!\!-OH + NaCl$$

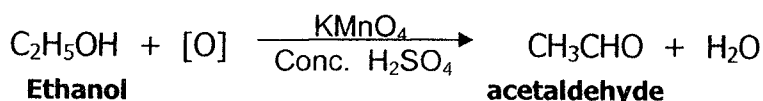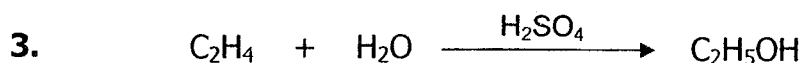$$\bigcirc\!\!-OH + 3HN \xrightarrow{Conc.\ H_2SO_4} \begin{array}{c} OH \\ O_2N\bigcirc NO \\ NO_2 \end{array} + 3H_2O$$

(Picric acid)

3.

$$C_2H_4 + H_2O \xrightarrow{H_2SO_4} C_2H_5OH$$

$$\underset{\text{Ethanol}}{C_2H_5OH} + [O] \xrightarrow[Conc.\ H_2SO_4]{KMnO_4} \underset{\text{acetaldehyde}}{CH_3CHO} + H_2O$$

$$\underset{\text{Acetaldehyde}}{CH_3CHO} + [O] \xrightarrow[Conc.\ H_2SO_4]{KMnO_4} \underset{\text{ethanoic acid}}{CH_3COOH}$$

4. Phenol from benzene.

$$\text{C}_6\text{H}_6 + Cl_2 \xrightarrow[\text{I.S.L}]{FeCl_3} \text{C}_6\text{H}_5Cl + HCl$$

$$\text{C}_6\text{H}_5Cl + NaOH \xrightarrow[\text{300 Atmospheres}]{300\ ^{\circ}C} \text{C}_6\text{H}_5OH + NaCl$$

- Benzene from Phenol

$$\text{Phenol} + Zn \xrightarrow{\text{Heat}} \text{Benzene} + ZnO$$

Answer of question (4)

A) 1. Catecol. 2. 2-propanol. 3. 1-propanol. 4. 2-propanol.

5. Picric acid 6. Catecol 7. Picric acid

B) 1. Experiment	Ethanol	2- Methyl - 2-butanol
By adding $KMnO_4$ solution and conc. H_2SO_4 to each of them.	The violet colour of potassium permanganate disappears.	No effect

2. Experiment	Secondary alcohol	Tertiary alcohol
By adding $KMnO_4$ solution and conc. H_2SO_4 to each of them.	The violet colour of potassium permanganate disappears.	No effect

C) 1- Tri-nitroglycerine.

2- It is used in the preparation of explosive substance.

3-

$$\text{C}_6\text{H}_5OH + 3 \xrightarrow{\text{Conc. } H_2SO_4} \text{(Picric acid)} + 3H_2O$$

4- Covalent bonds

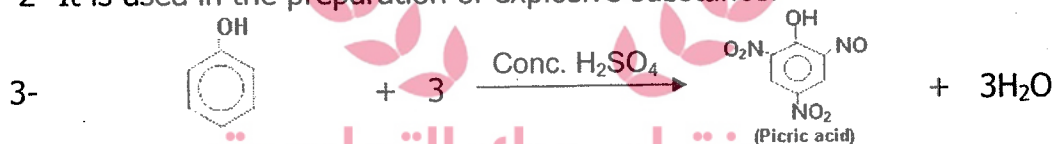**D) a)** The additives may be poisonous such as methanol (causes madness and blindness) or with bad odour e.g. pyridine and coloured dyes, the aim of that to be used as a fuel only and prevent its use as alcoholic liquors.

b) - It can be allowed to the driver to blow a balloon through a tube containing silica gel saturated with acidified potassium dichromate.

- The balloon is left till the exhalation goes out.

Observation:

- If the driver was drunk the colour of potassium dichromate in the tube changed from orange to green colour.

Answer of question (5)

A) 1.

$$\text{C}_6\text{H}_5Cl + NaOH \xrightarrow[\text{300 Atmospheres}]{300\ ^{\circ}C} \text{C}_6\text{H}_5OH + NaCl$$

$$\text{C}_6\text{H}_5OH + 3HNO_3 \xrightarrow{\text{Conc. } H_2SO_4} \text{(Picric acid)} + 3H_2O$$

2.

$$C_2H_5I + KOH \xrightarrow[\triangle]{Aq.} C_2H_5OH + KI$$

Ethyl bromide   **Ethanol**

$$C_2H_5OH + HCl \xrightarrow{ZnCl_2} C_2H_5Cl + H_2O$$
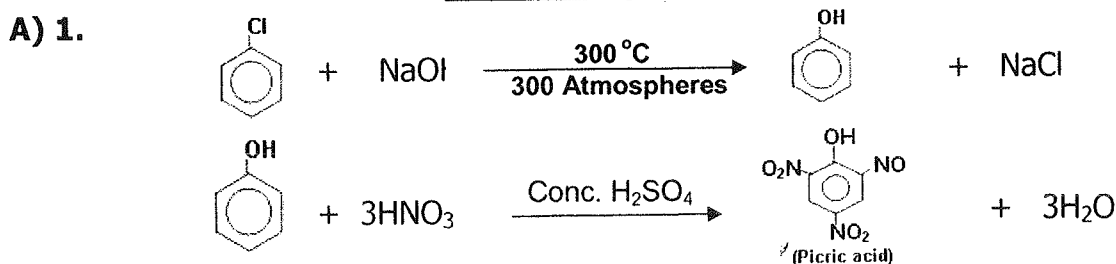
B) 1. a. It absorbs the water produced and prevents the reversible reaction.
     b. It converts glucose into ethanol (fermentation process).

$$C_6H_{12}O_6 \xrightarrow[\text{Zymase enzyme}]{\text{Yeast}} 2C_2H_5OH \text{ Ethanol } + 2CO_2$$

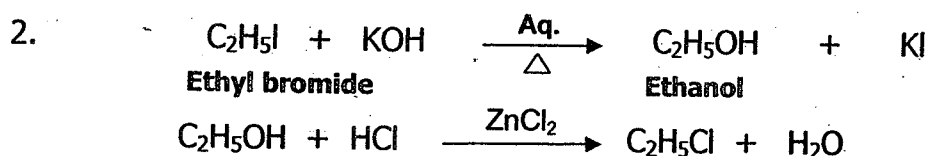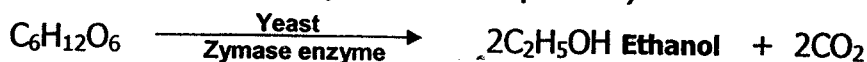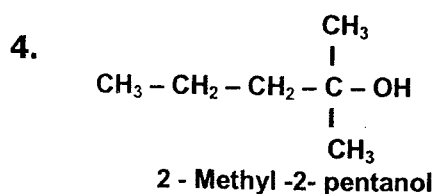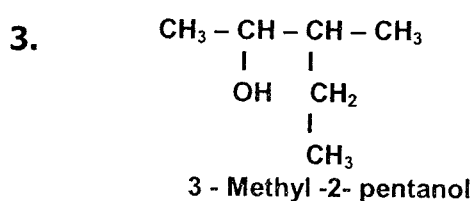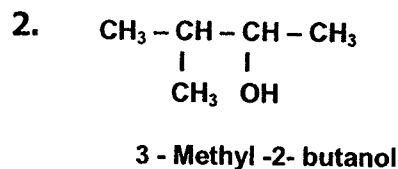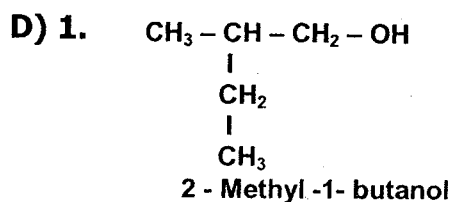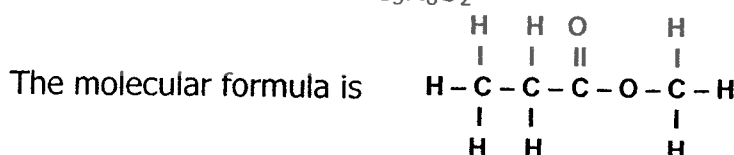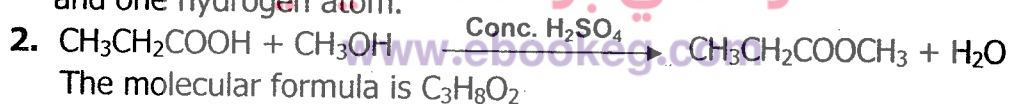| 2.	compound	Its uses
a	Ethanol	- Used in manufacture of creams and cosmetics as a moisturizer of skin. - used in manufacture of textiles, since it renders them soft and flexible. - used in the preparation of explosive substance of nitroglycerine. - Nitroglycerine is also used to widen arteries in the treatment of heart problems.
b	Ethylene glycol	- used as antifreeze substance in car radiators in cold countries. - Due to its high viscosity it is used as a constituent of the liquids used in the hydraulic brake in addition it is used in printing ink. - used to prepare polyethylene glycol (P.E.G) which is used in manufacture of Dacron fibers, photographic films and cassette tapes.
c	Glycerol	- used in manufacture of creams and cosmetics as a moisturizer of skin. - used in manufacture of textiles, since it renders them soft and flexible. - used in the preparation of explosive substance of nitroglycerine. - Nitroglycerine is also used to widen arteries in the treatment of heart problems.
d	Picric acid	- used in manufacturing explosives and in treatment of burns.
e	Bakelite	- used in manufacturing some electrical instruments and ash trays.

C) 1. Secondary alcohol because the carbinol group is attached to two carbon atoms and one hydrogen atom.

    2. $CH_3CH_2COOH + CH_3OH \xrightarrow{\text{Conc. } H_2SO_4} CH_3CH_2COOCH_3 + H_2O$

       The molecular formula is $C_3H_8O_2$

The molecular formula is

```
      H   H   O       H
      |   |   ||      |
  H – C – C – C – O – C – H
      |   |           |
      H   H           H
```

D) 1.
```
CH3 – CH – CH2 – OH
       |
       CH2
       |
       CH3
```
2 - Methyl -1- butanol

2.
```
CH3 – CH – CH – CH3
       |    |
       CH3  OH
```
3 - Methyl -2- butanol

3.
```
CH3 – CH – CH – CH3
       |    |
       OH   CH2
            |
            CH3
```
3 - Methyl -2- pentanol

4.
```
            CH3
            |
CH3 – CH2 – CH2 – C – OH
            |
            CH3
```
2 - Methyl -2- pentanol

Answer four only of the following questions

Question (1)

A) Choose the correct answer:

1. All these acids are mono carboxylic except .... acid.
   a) propanoic.   b) formic.   c) ethanoic.   d) phthalic.

2. ....acid an example of dibasic aromatic acid.
   a) benzoic.   b) phthalic.   c) formic.   d) oxalic acid.

3. Toluene is oxidized by air in the presence of V2O5 and gives ....
   a) benzoic acid.   b) phthalic acid.   c) acetic acid.   d) all of them.

4. Glycine is considered from .... acid
   a) hydroxyl.   b) aromatic.   c) amino.   d) fatty.

5. Insulin molecule is composed of 51 amino acids and it is considered an example of ....
   a) proteins.   b) carbohydrates.   c) fats.   d) oils.

6. Reduction of acetic acid by hydrogen in the presence of copper chromate gives.....
   a) copper acetate.   b) chromium acetate.   c) ethanol.   d) acetaldehyde.

B) Write the chemical equations that illustrate each of the following:

1) Conversion of acetic acid to normal ether.
2) Obtaining toluene from benzoic acid.
3) Formation of acetic acid from a petrochemical product.

C) How can you differentiate between each pair of the following:

1) Carbolic acid and acetic acid.   2) Ethyl alcohol and ethanoic acid.

Question (2)

A) Write the Scientific expression for each of the following:

1) Organic compounds having one carboxylic group or more.
2) Reaction of carboxylic acid with sodium carbonate or bicarbonate.
3) The number of carboxylic acid in an organic acid.
4) An organic compound is generated in human body as a result of hard effort.
5) An organic compound its lack in the human body leads to the infection by "Escarpot" disease, and the decrease in the biological functions.
6) Organic acid has two different functional groups.

B) Write the chemical equations that illustrate each of the following:

1) Reduction of acetic acid by hydrogen at 200 °C and presence of copper chromate.
2) Obtaining benzene from toluene.
3) Obtaining methane from acetic acid.
4) Obtaining ethylene glycol from acetic acid.

C) What is the simplest member of amino acids? Write its structural formula.

Question (3)

(A) Give reasons for:

1) Boiling point of carboxylic acids is higher than that of the corresponding alcohols.

2) Citric acid is added to frozen fruits.

3) Benzoic acid is monobasic whereas oxalic acid is a dibasic one.

4) Acetic acid CH_3COOH (pure 100%) is called glacial acetic acid.

5) Sodium benzoate 0.1 % is used, as preservating substance for foods.

6) Aspirin is used now instead of salicylic acid in treatment of cold diseases and headache

B) Write the molecular and structural formula for each of the following compounds:

1. Lactic acid.   2. Citric acid.

3. Oxalic acid.   4. Phthalic acid.

5. Salicylic acid.   6. Butanoic acid.

C) How can you obtain:

1) Acetic acid from calcium carbide.

2) Benzoic acid from calcium carbide.

3) Sodium ethoxide from acetic acid.

4) Sodium methoxide from acetic acid.

Question (4)

A) Write the structural formula of the compounds which have the following molecular formula:

1- Dicarboxylic aromatic acid $C_8H_6O_4$.

2- Aromatic acid contain a carboxylic group and one hydroxyl group $C_2H_6O_3$.

3- Dicarboxylic aliphatic acid $C_2H_2O_4$.

4- Aliphatic ether $C_4H_{10}O$.

5- Three alcohols having the molecular formula $C_4H_{10}O$.

B) Two organic compounds A and B.

- Compound (A) reacts with sodium metal but not with sodium hydroxide.

- Compound (B) reacts with both of sodium carbonate and sodium hydroxide.

From the above knowledge, answer the following questions:

a- To which group of compounds does each of compounds A and B belong?

Give an example for each group.

b- **Write** a **symbolic equation** for the reaction between the compounds (A) and (B), with referring to the conditions of the reaction.

C) Arrange the following compounds in ascending order with respect to increase in their acidity: OH   COOH

⬡ , HCl, CH_3COOH, ⬡ , CH_3OH
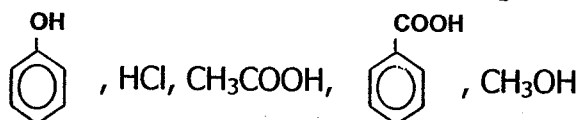
Question (5)

A)	Formic acid	Ethanoic acid	Oxalic acid
	Salicylic acid	Butyric acid	Benzoic acid

From the previous table mention the following:

1- Monocarboxylic acid.

2- Dicarboxyhc acid.

3- An acid in which the number of carboxylic groups equals the number of carbon atoms.

4- An acid contains two functional groups.

B) Write the name of the following compounds then explain how to prepare each one by neutralization process.

1- CH_3COOK 2- $(HCOO)_2Ca$

3- C_6H_5COONa 4- CH_3CH_2COONa

C) "Organic compounds play an important role in our daily life"
Mention the economic importance of each of the following:

1. Citric acid   2. Formic acid

3. Acetic acid   4. Ascorbic acid

5. Salicylic acid   6. Sodium benzoate

Answer exam (13) on carboxylic acids

Answer of question (1)

A) 1	2	3	4	5	6
d	b	a	c	a	c

B) 1) Conversion of acetic acid to normal ether.
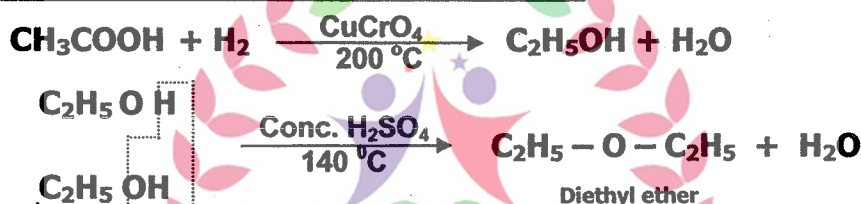
$$CH_3COOH + H_2 \xrightarrow[200\ ^\circ C]{CuCrO_4} C_2H_5OH + H_2O$$

$$\left.\begin{array}{l} C_2H_5\ O\ H \\ C_2H_5\ OH \end{array}\right\} \xrightarrow[140\ ^\circ C]{Conc.\ H_2SO_4} C_2H_5-O-C_2H_5 + H_2O$$

Diethyl ether

2) Obtaining toluene from benzoic acid.

3) Formation of acetic acid from a petrochemical product.

$$Petroleum\ products \xrightarrow[Catalytic\ cracking]{Thermal} C_2H_4$$

$$C_2H_4 + H_2O \xrightarrow{H_2SO_4} C_2H_5OH$$

$$\underset{Ethanol}{C_2H_5OH} + [O] \xrightarrow[Conc.\ H_2SO_4]{KMnO_4} \underset{acetaldehyde}{CH_3CHO} + H_2O$$

$$\underset{Acetaldehyde}{CH_3CHO} + [O] \xrightarrow[Conc.\ H_2SO_4]{KMnO_4} \underset{acetic\ acid}{CH_3COOH}$$
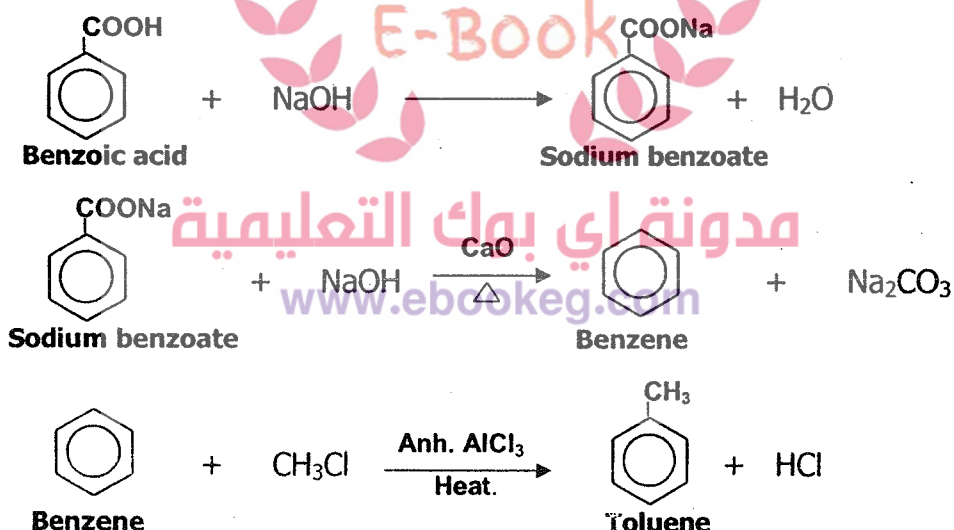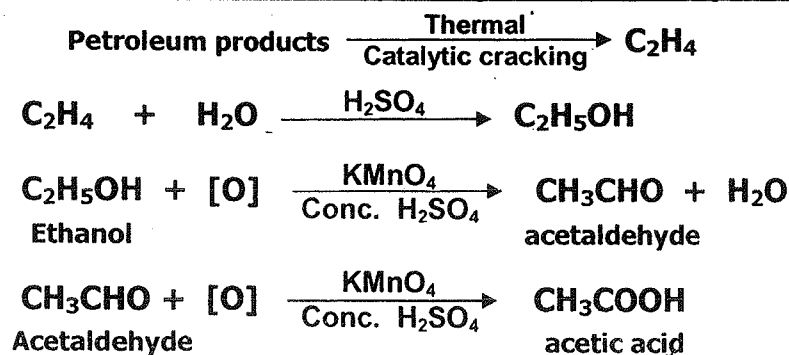
C) 1.

Experiment	Acetic acid	Phenol (Carbolic acid)
By adding Na_2CO_3 solution to each of them	Effervescence takes places and CO_2 evolves which turbids lime water	No effect

2. Experiment	Acetic (ethanoic) acid	Ethyl alcohol (ethanol)
By adding Na_2CO_3 solution to each of them	Effervescence takes places and CO_2 evolves which turbids lime water	No effect

Answer of question (2)

A) 1. Carboxylic acids.   **2.** Acidity test.   **3.** Basicity of acids
   4. Lactic acid.   **5.** Ascorbic acid.   **6.** Salicylic acid.

B) 1) Reduction of acetic acid by hydrogen at 200 °C and presence of copper chromate.

$$CH_3COOH + H_2 \xrightarrow[200\ °C]{CuCrO_4} C_2H_5OH + H_2O$$

2) Obtaining benzene from toluene.

$$2\ C_6H_5CH_3 + 3O_2 \xrightarrow[400\ °C]{V_2O_5} 2\ C_6H_5COOH + 2H_2O$$

$$C_6H_5COOH + NaOH \longrightarrow C_6H_5COONa + H_2O$$

$$C_6H_5COONa + NaOH \xrightarrow[\Delta]{CaO} C_6H_6 + Na_2CO_3$$

3) Obtaining methane from acetic acid.

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

$$CH_3COONa + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$
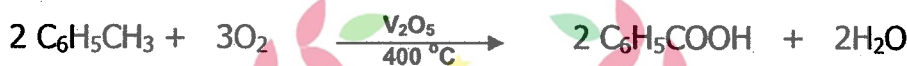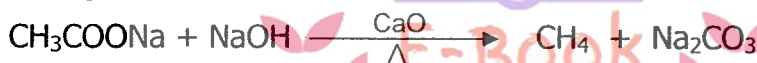
4) Obtaining ethylene glycol from acetic acid.

$$CH_3COOH + 2H_2 \xrightarrow[200\ °C]{CuCrO_4} C_2H_5OH + H_2O$$

$$C_2H_5OH \xrightarrow[180\ °C]{Conc.\ H_2SO_4} C_2H_4 + H_2O$$

$$C_2H_4 + H_2O + [O] \xrightarrow[Alkaline\ medium]{KMnO_4} C_2H_4(OH)_2 \quad [\text{ethylene glycol}]$$
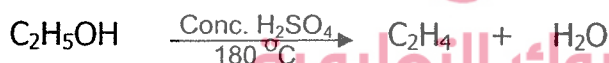
C) The simplest member of amino acids is glycine.

Its structural formula is

$$\begin{array}{ccc} H & H & O \\ | & | & \| \\ H-N & -C & -C-OH \\ & | & \\ & H & \end{array}$$
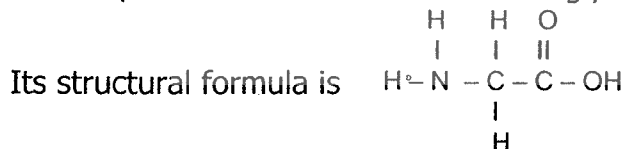
Answer of question (3)

A) 1. Because in acids each two molecules are linked together by two hydrogen bonds, so, it needs higher energy to be broken, while in alcohols, each two molecules are linked together with one hydrogen bonds, so it needs lower energy to be broken.

2. Because it decreases the pH. Thus, it prevents the growth of bacteria and keeps their colours and taste.

3. Because benzoic acid contains one carboxylic group while oxalic acid contains two groups.

4. Because it freezes at 16 °C forming solid substance like ice.

5. This is because it prevents the growth of fungi on foods.

6. Because salicylic acid causes the bleeding of stomach.

B)

1. Lactic acid.
Molecular formula: $C_3H_6O_3$, Structural formula:

$$CH_3 - \underset{\underset{OH}{|}}{C}H - COOH$$

2. Citric acid.
Molecular formula: $C_6H_8O_7$, Structural formula:

$$\begin{array}{c} H \\ | \\ H - C - COOH \\ | \\ HO - C - COOH \\ | \\ H - C - COOH \\ | \\ H \end{array}$$

3. Oxalic acid
Molecular formula: $C_2H_2O_4$, Structural formula:

$$\begin{array}{c} COOH \\ | \\ COOH \end{array}$$

4. Phthalic acid
Molecular formula: $C_6H_6O_4$, Structural formula:

5. Salicylic acid
Molecular formula: $C_7H_6O_3$, Structural formula:

6. Butanoic acid
Molecular formula: $C_4H_8O_2$, Structural formula:

$$\begin{array}{c} H \quad H \quad H \quad O \\ | \quad\; | \quad\; | \quad\; \| \\ H - C - C - C - C - OH \\ | \quad\; | \quad\; | \\ H \quad H \quad H \end{array}$$

C) 1) Acetic acid from calcium carbide.
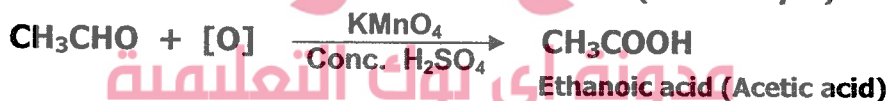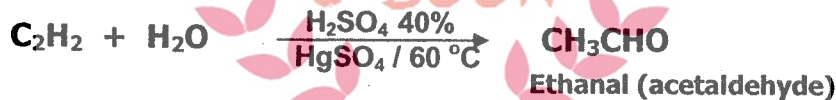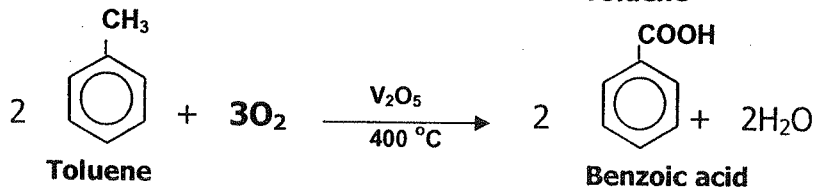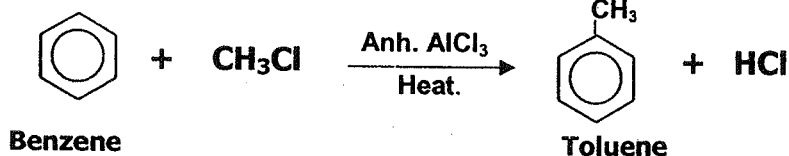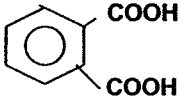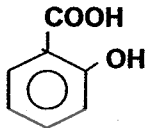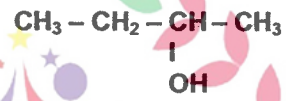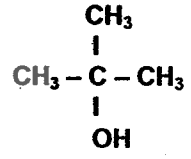
$$CaC_2 + 2H_2O \xrightarrow{\text{Dropping}} C_2H_2 + Ca(OH)_2$$

$$C_2H_2 + H_2O \xrightarrow[\text{HgSO}_4 / 60\,°C]{H_2SO_4\ 40\%} CH_3CHO$$

Ethanal (acetaldehyde)

$$CH_3CHO + [O] \xrightarrow[\text{Conc. } H_2SO_4]{KMnO_4} CH_3COOH$$

Ethanoic acid (Acetic acid)

2) Benzoic acid from calcium carbide.

$$CaC_2 + 2H_2O \xrightarrow{\text{Dropping}} C_2H_2 + Ca(OH)_2$$

$$3C_2H_2 \xrightarrow{\text{Red hot nickel tube}} C_6H_6$$

3) Sodium ethoxide from acetic acid.

$$CH_3COOH + 2H_2 \xrightarrow[200\,°C]{CuCrO_4} C_2H_5OH + H_2O$$

$$2\,C_2H_5OH + 2\,Na \longrightarrow 2\,C_2H_5ONa + H_2$$

4) Sodium methoxide from acetic acid.

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

$$CH_3COONa + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$

$$CH_4 + Cl_2 \xrightarrow{\textbf{Indirect sunlight}} CH_3Cl + HCl$$

$$CH_3Cl + KOH \textbf{ (aq)} \xrightarrow{\textbf{Heat}} CH_3OH + KCl$$

$$2CH_3OH + 2Na \longrightarrow 2CH_3ONa + H_2$$

Answer of question (4)

A)

1. **Phthalic acid** (benzene ring with two COOH groups)

2. (benzene ring with COOH and OH)

3. $\begin{array}{c} COOH \\ | \\ COOH \end{array}$ **Oxalic acid**
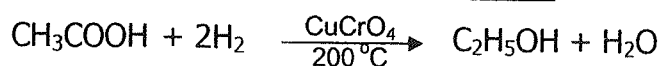
4. $CH_3 - CH_2 - O - CH_2 - CH_3$ and $CH_3 - O - CH_2 - CH_2 - CH_3$

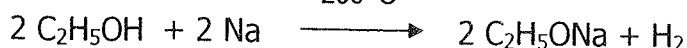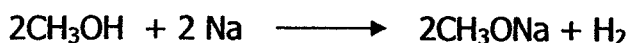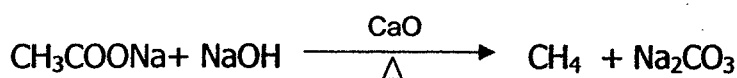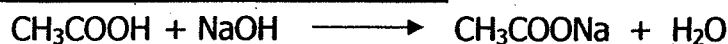5. $CH_3 - CH_2 - CH_2 - CH_2 - OH$, $CH_3 - CH_2 - \underset{\underset{OH}{|}}{CH} - CH_3$, $CH_3 - \underset{\underset{OH}{|}}{\overset{\overset{CH_3}{|}}{C}} - CH_3$

B) - Compound (A) belongs alcohols, example: ethanol (C_2H_5OH).

- Compound (B) belongs carboxylic acid, example: acetic acid (CH_3COOH).

$$CH_3COOH + C_2H_5OH \xrightarrow{\textbf{Conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$$

- Concentrated sulphuric acid is added to absorb the produced water and prevents the reversible reaction.

C) Arrangement of the compounds in ascending order with respect to increase in their acidity:

$$CH_3OH < \text{(phenol)} < CH_3COOH < \text{(benzoic acid)} < HCl$$

Answer of question (5)

A) 1. Monocarboxylic acids are:

Formic acid, Ethanoic acid, Salicylic acid, Butyric acid and Benzoic acid.

2. Dicarboxylic acid is oxalic acid.

3. Formic acid and oxalic acid.

4. Salicylic acid

B) 1- CH_3COOK is named potassium acetate.

$$CH_3COOH + KOH \longrightarrow CH_3COOK + H_2O$$
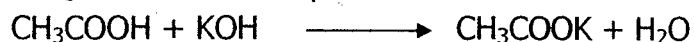
2- $(HCOO)_2Ca$ is named calcium formate.

$$2HCOOH + Ca(OH)_2 \longrightarrow (HCOO)_2Ca + H_2O$$
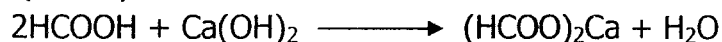
3- C_6H_5COONa is named sodium benzoate.

$$C_6H_5COOH + NaOH \longrightarrow C_6H_5COONa + H_2O$$
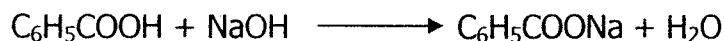
4- CH_3CH_2COONa is named sodium propanoate.

$$CH_3CH_2COOH + NaOH \longrightarrow CH_3CH_2COONa + H_2O$$
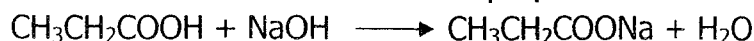
C)	Organic compound	The economic importance
1	Citric acid	- It prevents the growth of bacteria in foods. - it is added to food to retain their colour and taste. - It has many industrial uses
2	Formic acid	- It is used in manufacture of: 1. Perfumes. 2. Dyes. 3. Plastic 4. Drugs 5. Insecticides
3	Acetic acid	- It is considered as a starting material for the synthesis of many organic products: (Synthetic silk-Food additives insecticides-dyes) - Acetic acid (4%) is used as vinegar in homes.
4	Ascorbic acid	- The human body needs it in the form of vitamin (C).
5	Salicylic acid	- Manufacture of Cosmetics for skin softening and protection against harmful rays of sun. - Manufacture of aspirin and Marookh oil.
6	Sodium benzoate	- It is used as a preservative for foods.

Sami Book

In

Chemistry

Graduated Exams with the model answers

Examinations of General Secondary Certificate

with the model answers

Exam (14) on esters

Answer four only of the following questions

Question (1)

A) Choose the correct answer:

1. Marookh oil is obtained from the reaction of salicylic acid with ....
   a) acetyl chloride. b) acetic acid. c) methanol. d) ethanol.

2. The isomer of ethyl acetate is ....
   a) ethyl formate. b) methyl propanoate. c) methyl formate. d) ethanoic acid.

3. The isomer of methyl benzoate is ....
   a) ethyl formate. b) phenyl acetate. c) ethyl benzoate. d) phenyl formate

4. The ester that gives ethanoic acid on hydrolysis is ....
   a) $C_6H_5COOCH_3$ b) $C_2H_5COOCH_3$ c) $CH_3COOC_6H_5$ d) $C_2H_5COOC_2H_5$

5. The ester that gives benzamide on ammonolysis is ....
   a) $C_6H_5COOCH_3$ b) $C_2H_5COOCH_3$ c) $CH_3COOC_6H_5$ d) $C_2H_5COOC_2H_5$

6. Oil and fats are esters obtained from combination of fatty acid with.......
   a) ethanol. b) ethylene glycol. c) glycerol. d) No correct answer.

B) Write the chemical equations that illustrate each of the following:

1) Effect of methanol on salicylic acid.
2) Effect of acetic acid on salicylic acid.
3) Obtaining triglyceride from glycerol.

C) Compare between each pair of the following:

1) Acid hydrolysis and alkaline hydrolysis of esters.
2) Addition polymerization and condensation polymerization.

Question (2)

A) Write the Scientific expression for each of the following:

1) Reaction of acid with alcohol in presence of conc. H_2SO_4.
2) Reaction of ester with ammonia to give an acid amide and alcohol.
3) An ester produced from reaction of salicylic acid with acetic acid.
4) Heating esters with an alkaline solution.
5) An ester produced from reaction of salicylic acid with methanol.

B) Methyl acetate	Sodium acetate	Ethanoic acid
Methyl formate	Potassium acetate	Ethyl formate

From the previous table illustrate the following:

1- The esters
2- The salts of the carboxylic acids.
3- The compounds which take a name according to IUPAC system.
4- The isomeric compounds.

C) Write the chemical equations that illustrate each of the following:

1) Obtaining an acid amide from ethanol.
2) Obtaining an Benz amide from benzoic acid.
3) Condensation of ethylene glycol with terphthalic acid.
4) Obtaining ethyl acetate from ethyl iodide.

Question (3)

A) Give reasons for:

1) Cone. Sulphuric acid is added in ester formation and nitration.
2) Boiling points of esters are lower than those of acids and alcohols forming them.
3) Esters are used in the manufacture of perfumes and flavors.
4) Aspirin is preferred than salicylic acid in the treatment of headache and cold.
5) Some types of aspirin are mixed with aluminum hydroxide.
6) Formation of esters from acids and alcohols takes place in the presence of dehydrating agents.

B) Arrange the following organic compounds in ascending order according to their boiling points, give the scientific reason.

(Acetic acid – Methyl formate – propanol)

C) Write the chemical equations that illustrate each of the following:

1) Conversion of benzene to benzamide.
2) Reaction of benzoic acid with ethanol in the presence of dry HCl then reacting the product with ammonia.
3) The product of hydrolysis and ammonolysis of these esters.
   a) $CH_3CH_2COOC_6H_5$
   b) $C_6H_5COOCH_2CH_3$

Question (4)

A) Aspirin	$(COO)_2Ca$	$C_6H_5COO\ CH_3$
$CH_3COOC_6H_5$	Vitamin C	Dacron

From the previous table define the following:

1- The esters.
2- The carboxylic acids.
3- The ester produced from the reaction of benzoic acid and methanol.
4- The ester produced from the reaction of acetic acid and phenol.
5- Two isomeric compounds.

B) Give reasons for:

1) Doctors' advice to crush the aspirin tablet as a powder before swallowing or taking it dissolved in water.
2) Salicylic acid can react as an organic acid or phenol.
3) Esters have a medical value.
4) Esters are used in many of food industries.

C) Why the solubility of the ester in water is less than the solubility of the corresponding acid which contains the same number of carbon atom.

Question (5)

A) Aspirin and Marookh oil are used as medical esters and they derived from salicylic acid. Look at the following structure then answer the below questions:
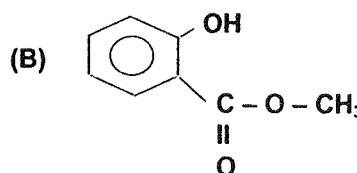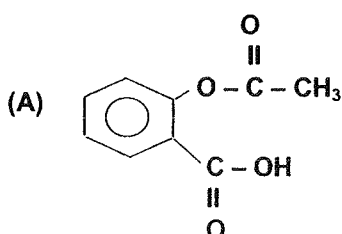
Which formula represents to Aspirin and which represents Marookh oil, then' show

1) The method used to prepare each of them.
2) The type and number of functional groups in each of them.
3) The compound that gives violet colour with iron III chloride (explain why?)
4) The compound that cause effervescence when it reacts with sodium bicarbonate (Explain why?)
5) The product of reaction of each of them with NaOH on cold.
6) The product of ammonolysis of each of them.

B) What is meant by saponification? What is the economic importance of this process?

C) "Organic compounds play an important role in our daily life"
Mention the economic importance of each of the following:

1- Aspirin.   2- Dacron fibers.   3- Oils and fats.
4- Esters.   5- Maroohk oil.   6- Salicylic acid.

D) Write the common and IUPAC names of the following esters:

1) $CH_3 - CH_2 - \overset{\overset{O}{\|}}{C} - O - CH_3$

2) $H - \overset{\overset{O}{\|}}{C} - O - CH_3$

3) $CH_3 - CH_2 - CH_2 - \overset{\overset{O}{\|}}{C} - O - CH_3$

4) $\underset{\text{(benzene ring)}}{\bigcirc} \overset{\overset{O}{\|}}{C} - O - CH_2 - CH_3$

5) $CH_3 - CH_2 - \overset{\overset{O}{\|}}{C} - O - \underset{\text{(benzene ring)}}{\bigcirc}$
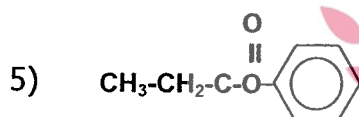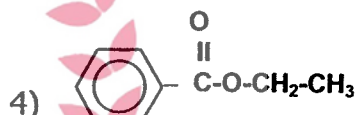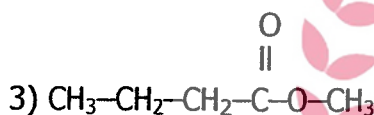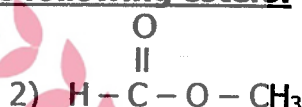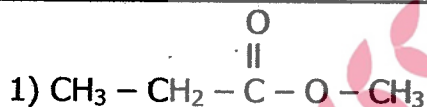
Answer Exam (14) on esters

Answer of question (1)

(A)

1	2	3	4	5	6
c	b	b	c	a	c

B) 1.

Salicylic acid + H-O-CH$_3$ → Oil of winter green (Methyl salycilate) + H_2O

2.

Salicylic acid + HO-C-CH$_3$ → Aspirin (acetyl salicylic acid) + H_2O

3.

$$\underset{\text{Glycerol}}{\begin{array}{c} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array}} \quad + \quad \underset{\text{3 Molecules of fatty acid}}{\begin{array}{c} \overset{O}{\overset{||}{HO-C-R_1}} \\ \overset{O}{\overset{||}{HO-C-R_2}} \\ \overset{O}{\overset{||}{HO-C-R_3}} \end{array}} \quad \longrightarrow \quad \underset{\text{Triglyceride ester}}{\begin{array}{c} \overset{O}{\overset{||}{CH_2-O-C-R_1}} \\ | \\ \overset{O}{\overset{||}{CH-O-C-R_2}} \\ | \\ \overset{O}{\overset{||}{CH_2-O-C-R_3}} \end{array}} \quad + \quad 3\,H_2O$$

C) 1. Alkaline hydrolysis of esters	Acidic hydrolysis esters
1. Hydrolysis of ester in presence of aqueous alkali e.g.(aqueous NaOH)	1. Hydrolysis of ester in presence of dilute mineral acid e.g.(H_2SO_4)
2. Gives an alcohol and the salt of the acid.	2. Gives an alcohol and organic acid.
3. Example: $CH_3COOC_2H_5$ + NaOH $\longrightarrow CH_3COONa+C_2H_5OH$	3. Example: $CH_3COOC_2H_5$ + H_2O $\xrightarrow{H^+}$ C_2H_5OH + CH_3COOH

Addition polymerization	Condensation polymerization
Combination of a large number of unsaturated simple molecules (monomers) to give a giant molecule (polymer) having the same empirical formula. (e.g. Ethylene glycol)	Condensation of two different monomers to give a new monomer called copolymer which undergoes polymerization. (e.g. Dacron)

Answer of question (2)

A) 1. Ester formation (estrification).

   2. Ammonolysis.

   3. Aspirin.

   4. Alkaline hydrolysis.

   5. Marookh oil.

B) 1- The esters are:

   Methyl acetate, methyl formate and ethyl formate.

   2- The salts of the carboxylic acids are:

   Sodium acetate and Potassium acetate.

   3- The compound which takes a name according to IUPAC system is:

   Ethanoic acid.

  4- The isomeric compounds:

   - Methyl acetate and ethyl formate are isomers.

   - Ethanoic acid and methyl formate are isomers.

C) 1) Obtaining an acid amide from ethanol:
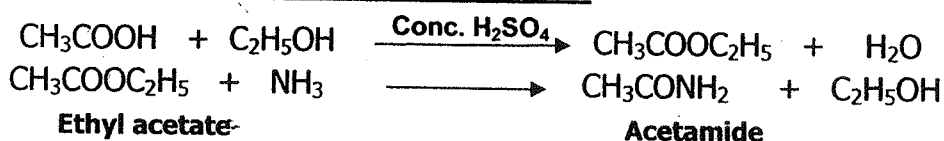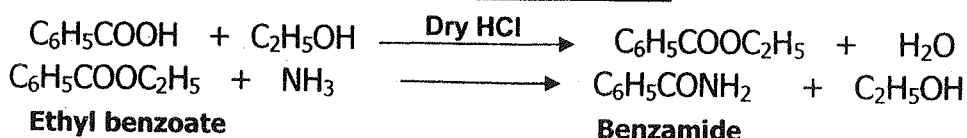
$$CH_3COOH \; + \; C_2H_5OH \; \xrightarrow{\text{Conc. } H_2SO_4} \; CH_3COOC_2H_5 \; + \; H_2O$$
$$\underset{\text{Ethyl acetate}}{CH_3COOC_2H_5} \; + \; NH_3 \; \longrightarrow \; \underset{\text{Acetamide}}{CH_3CONH_2} \; + \; C_2H_5OH$$

2) Obtaining an Benz amide from benzoic acid:

$$C_6H_5COOH \; + \; C_2H_5OH \; \xrightarrow{\text{Dry HCl}} \; C_6H_5COOC_2H_5 \; + \; H_2O$$
$$\underset{\text{Ethyl benzoate}}{C_6H_5COOC_2H_5} \; + \; NH_3 \; \longrightarrow \; \underset{\text{Benzamide}}{C_6H_5CONH_2} \; + \; C_2H_5OH$$

3) Condensation of ethylene glycol with terphthalic acid.

$$HO - \overset{\overset{O}{\|}}{C} - \bigcirc - \overset{\overset{O}{\|}}{C} - OH \qquad + \qquad \begin{array}{c} HO - CH_2 - CH_2 - OH \\ \textbf{Ethylene glycol} \end{array}$$

Terphthalic acid

$$\downarrow -H_2O$$

Attack by an alcohol $\longrightarrow HO - \overset{\overset{O}{\|}}{C} - \bigcirc - \overset{\overset{O}{\|}}{C} - O - CH_2 - CH_2 - OH \longleftarrow$ **Attack by an acid**

4) Obtaining ethyl acetate from ethyl iodide.

$$C_2H_5I + KOH \xrightarrow[\triangle]{Aq.} C_2H_5OH + KI$$
Ethyl iodide   **Ethanol**

$$CH_3COOH + C_2H_5OH \xrightarrow{Conc.\ H_2SO_4} CH_3COOC_2H_5 + H_2O$$
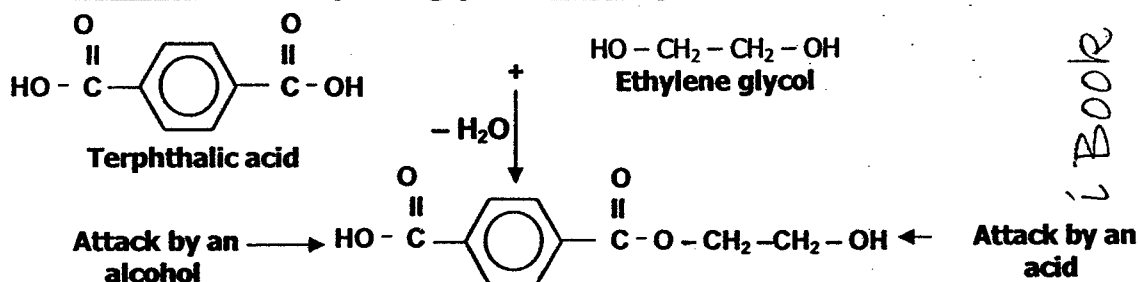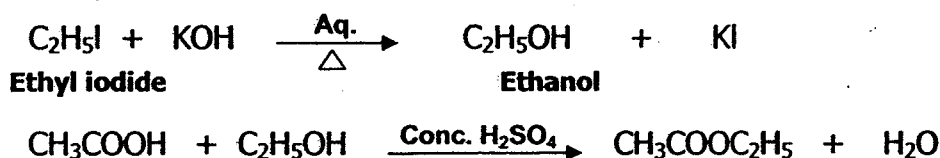
Answer of question (3)

A) 1. To absorb the produced water and prevents the reversible reaction.
    2. Due to the absence of hydrogen bonds in esters.
    3. Because esters have pleasant smells and tastes.
    4. Because salicylic acid causes the bleeding of stomach.
    5. To neutralize its acidity and avoid stomach ulcer.
    6. To absorb the produced water and prevents the reversible reaction.

B) Methyl formate < propanol < Acetic acid
  - The scientific base: Methyl formate is an ester therefore it has no hydrogen bonds.
Propanol is an alcohol therefore there is one hydrogen bond between each two molecules.
Acetic acid is an acid therefore there is two hydrogen bonds between each two molecules.

C) 1) Conversion of benzene to benzamide:
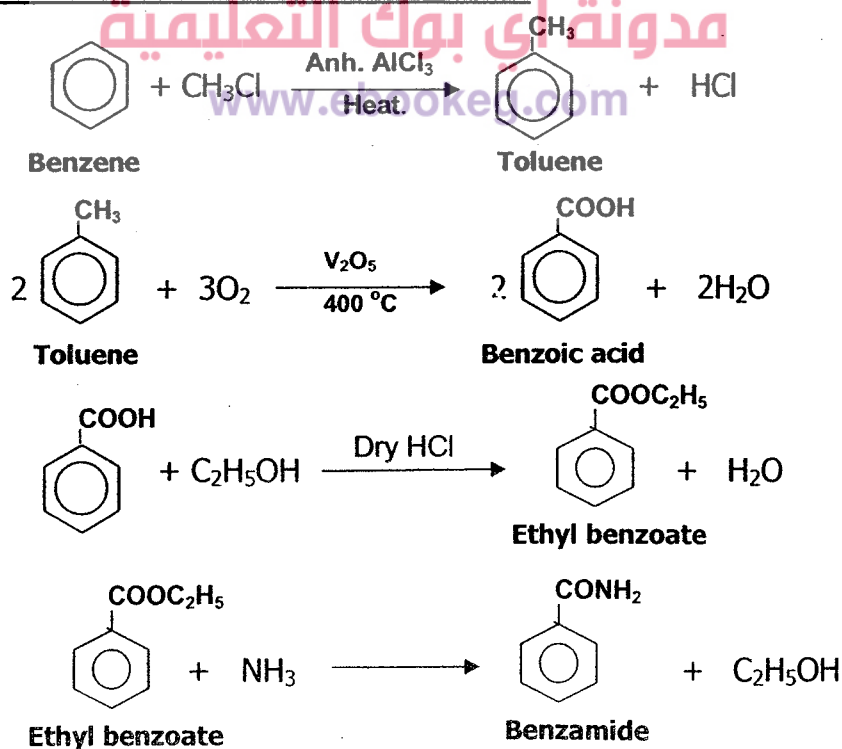
$$\bigcirc + CH_3Cl \xrightarrow[Heat.]{Anh.\ AlCl_3} \overset{CH_3}{\bigcirc} + HCl$$

Benzene   **Toluene**

$$2\,\overset{CH_3}{\bigcirc} + 3O_2 \xrightarrow[400\ ^oC]{V_2O_5} 2\,\overset{COOH}{\bigcirc} + 2H_2O$$

Toluene   **Benzoic acid**

$$\overset{COOH}{\bigcirc} + C_2H_5OH \xrightarrow{Dry\ HCl} \overset{COOC_2H_5}{\bigcirc} + H_2O$$

Ethyl benzoate

$$\overset{COOC_2H_5}{\bigcirc} + NH_3 \longrightarrow \overset{CONH_2}{\bigcirc} + C_2H_5OH$$

Ethyl benzoate   **Benzamide**

2) Reaction of benzoic acid with ethanol in the presence of dry HCl then reacting the product with ammonia.

Benzoic acid

$$C_6H_5COOH + C_2H_5OH \xrightarrow{\text{Dry HCl}} C_6H_5COOC_2H_5 + H_2O$$

Ethyl benzoate

$$C_6H_5COOC_2H_5 + NH_3 \longrightarrow C_6H_5CONH_2 + C_2H_5OH$$

Ethyl benzoate   Benzamide

3) The product of hydrolysis and ammonolysis of these esters.

a) $CH_3CH_2COOC_6H_5 + H_2O \xrightarrow{H^+} CH_3CH_2CONH_2 + C_6H_5OH$

b) $C_6H_5COOCH_2CH_3 + H_2O \xrightarrow{H^+} C_6H_5CO\,NH_2 + CH_2CH_3OH$
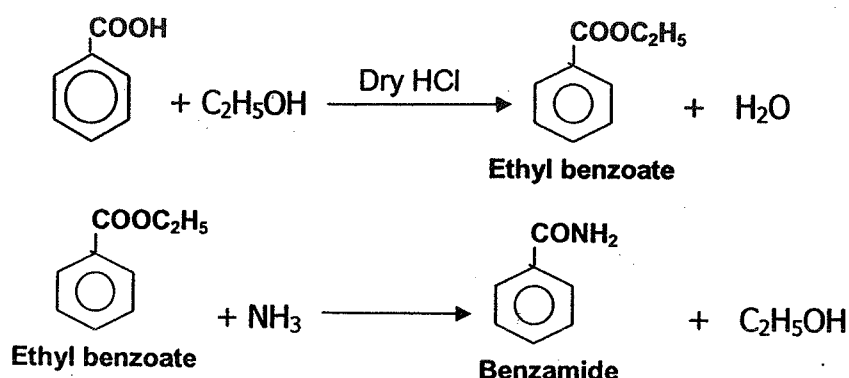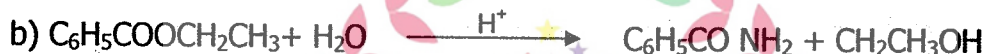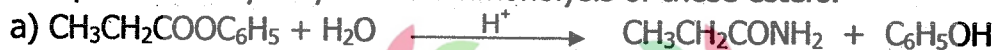
Answer of question (4)

A) 1- The esters:

Aspirin, $C_6H_5COOCH_3$, $CH_3COOC_6H_5$ and Dacron

2- The carboxylic acids:

Aspirin and Vitamin C

3- The ester produced from the reaction of Benzoic acid and Methanol:

$C_6H_5COOCH_3$

4- The ester produced from the reaction of Acetic acid and Phenol:

$CH_3COOC_6H_5$

5- Two isomeric compounds:

$C_6H_5COOCH_3$ and $CH_3COOC_6H_5$

B) 1. Because aspirin is hydrolyzed in the body to produce salicylic acid and acetic acid. The produced acids cause the excitation of stomach walls and may cause stomach ulcer.

2. Because it reacts as acid because it contains carboxylic group and as alcohol (phenol) because it contains hydroxyl group.

3. This is because esters are used in the manufacture of many drugs; the most common and simplest one is aspirin and oil of winter green (Marookh oil).

4. Because esters are characterized by pleasant smell and taste.

C) This is due to the absence of the polar hydroxyl group in the ester and presence of it in the acid. This polar hydroxyl group caused the attraction of the acid molecules to the polar water molecules causing solubility.

Answer of question (5)

A) The compound (A) is Aspirin formula and compound (B) is Marookh oil formula

1- Marookh is prepared by reaction of salicylic acid with methyl alcohol.
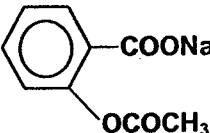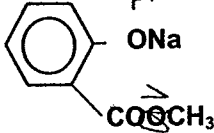
Aspirin is prepared by reaction of salicylic acid with acetic acid.
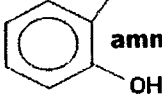
2- Functional groups in aspirin are - COOH & - COO⁻ while functional groups in Marookh oil are OH and - COO⁻.

3- Marookh oil; as it has OH phenolic group.

4- Aspirin; as it has - COOH group

5-

The compound **(A)** gives $\langle\bigcirc\rangle$—COONa   The compound **(B)** gives $\langle\bigcirc\rangle$- ONa

with OCOCH₃ and COOCH₃ substituents respectively.

6- The compound **(A)** gives Acetamide [CH₃CONH₂⁺] + benzene ring with COONH₄ and OH groups — **ammonium salicylate**

The compound **(B)** gives CH₃OH + salicyamide (benzene ring with OH and CONH₂ groups)
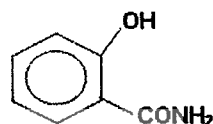
B) Saponification process is hydrolysis of fat or oil (triglyceride ester) in the presence of strong alkali e.g. (NaOH) or (KOH).

The economical importance:

It is the principle reaction in the manufacture of soap and glycerol in the industry.

C)	compound	The economic importance
1	**Aspirin**	- It reduces the headache pains. - It reduces fever (high temperature). - It reduces blood clotting.
2	**Dacron fibers**	- It is used to substitute the spoiled arteries. - It is used in manufacture of artificial heart valves.
3	**Oils and fats**	- Manufacture of **soap** and **glycerol** in the industry.
4	**Esters**	- They are used in food industry as flavours. - Acts as monomer in preparation of polyester as Dacron. - They are used in manufacture of many drugs as: 1. Aspirin 2.Marookh oil.
5	**Maroohk oil**	- It is absorbed by the skin to decrease the pains of rheumatism.
6	**Salicylic acid**	- Manufacture of Cosmetics for skin softening and protection against harmful rays of sun. - Manufacture of aspirin and Marookh oil.

D)

1. Methyl propanoate.

2. Methyl formate, Methyl methanoate.

3. Methyl butyrate, Methyl butanoate.

4. Ethyl benzoate.

5. Phenyl propanoate.

Answer four only of the following questions

Question (1)

(A) Choose the correct answer for each statement of the following :

1. Reaction of acids with alcohols in presence of a dehydrating agent is called....
   a) hydration.   b) esterification.   c) neutralization.   d) oxidation.

2. .... acid is an example of dibasic aromatic acid.
   a) benzoic.   b) phthalic.   c) formic.   d) oxalic.

3. The following reaction is called ......

   $$C_6H_{12}O_6 \longrightarrow 2\ C_2H_5OH + 2CO_2$$

   a) polymerization.   b) esterification.   c) Saponification.   d) fermentation.

4. Catalytic hydration of propene gives ......
   a) primary alcohol.   b) secondary alcohol.   c) tertiary alcohol.   d) dihydric alcohol

5. All these alcohols are oxidized by acidified potassium permanganate except ...
   a) 2 - methyl - 2 propanol.   b) ethanol   c) iso – propanol.   d) methanol .

6. Oxidation of isopropanol gives ....
   a) acetone.   b) acetaldehyde.   c) ethanol.   d) acetic acid.

B) Write the chemical equations that illustrate each of the following:

1. Effect of a mixture of conc. Nitric acid and sulphuric acids on both of glycerol and phenol.
2. Formation of dihydric alcohol from a monohydric one.
3. Addition of water to 2 - methyl - 2 - butene.

C) Arrange the following compounds in ascending order according to their boiling points:

   Glycerol - ethanol - ethylene glycol - Sorbitol

D) Two organic compounds (A) and (B)
   - Compound (A) reacts with sodium metal but not with sodium hydroxide.
   - Compound (B) reacts with both of sodium bicarbonate and sodium hydroxide.

   From the above knowledge, answer the following questions:
   1. To which group of compounds does each of compound (A) and (B) belong?
   2. Write a symbolic equation for the reaction between the compounds (A) and (B) with referring to the condition of the reaction.

Question (2)

A) Write the scientific expression for each of the following:

1. The number of carboxylic groups in an organic acid.
2. Polyhydroxy aldehydes or polyhydroxy ketones.
3. The reaction of alcohols with carboxylic acids in the presence of a dehydrating agent.
4. Organic compounds having (- CH$_2$OH) group in their structures.

B) How can you obtain:

1. Acetone from iso-propanol.   2. Phenol from benzene and vice versa.
3. Acetic acid from calcium carbide.   4. Methane from ethyne

C) How can you differentiate between each pair of the following:

   1. Ethanol and phenol.   2. Carbolic acid and ethanoic acid.

Question (3)

A) 2 – propanol	1 - propanol	Picric acid
2 – methyl – 1 - propanol	2 – methyl – 2 - propanol	catechol

Choose from the above table , the compound (or compounds) that considered from :

1. Primary alcohols.
2. Secondary alcohols.
3. Phenols.
4. Alcohols which give aldehydes on oxidation.
5. Alcohols which give ketones on oxidation.
6. Product of nitration of phenol.
7. Disubstituted benzene.
8. Tetra substituted benzene.

B) Organic compounds play an important role in our daily life . mention the economic importance of each of the following :

1. Ethylene glycol
2. Glycerol
3. Picric acid
4. Ethanol
5. Phenol
6. Bakelite

C) How can you obtain :

1. Diethyl ether from ethylene.
2. Methanol from acetic acid.

Question (4)

A) A and B are two organic compounds having the molecular formula [C_2H_6O].

1. Write the structural formula for each compound.
2. If compound (A) responds to oxidation reactions and compound (B) does not. How can you convert compound (A) to a compound that has the function group of compound (B)?
3. How can you obtain hydrogen from one of the two compounds?

B) Show by balanced chemical equations:

1. The reaction of ethanol with concentrated sulphuric acid at 180°C.
2. A mixture of ethyl alcohol and concentrated sulphuric acid is heated at 140°C.
3. Reaction of conc. nitric acid with phenol in the presence of conc. sulphuric acid.
4. Reaction of conc. nitric acid with glycerol in the presence of conc. sulphuric acid.

C) Give reasons for:

1. Phenol is more acidic than ethanol.
2. Conc. Sulphuric acid is added in ester formation and nitration.
3. Benzoic acid is monobasic whereas, oxalic is a dibasic one.
4. Caustic soda reacts with phenol and not reacted with ethanol.
5. Bakelite is used in manufacture of electric instruments.
6. The boiling point of carboxylic acids is higher than that of the corresponding alcohols.

Question (5)

A) A, B, C and D are four functional groups:

(- OH)	(- O -)	(- CHO)	(- COOH)
(A)	(B)	(C)	(D)

1. Write the name of functional group.
2. What is the class of the compounds having a functional group from them?
3. Give an example for an organic compound having a functional group from them.
4. Show by chemical equations how to convert an organic compound having the functional:
   a) (A) to another having a functional group (B)
   b) (D) to another having a functional group (A)
   c) (C) to another having a functional group (A)
   d) (A) to another having a functional group (C)

B) Write the structural formula of the compounds which have the following molecular formula:

1. Dicarboxylic aromatic acid $C_8H_6O_4$.
2. Dicarboxylic aliphatic acid $C_2H_2O_4$.
3. Aliphatic ether $C_4H_{10}O$.
4. Three alcohols having the molecular formula $C_4H_{10}O$

C) Write the chemical name for the following compound:

1.
   OH
   OH (benzene ring)

2.
   $CH_2 - CH_2$
   $||$
   $OHOH$

D) Arrange the following compounds in ascending order with respect to increase in their acidity:

O (benzene ring) , HCl , CH_3COOH , COOH (benzene ring) , CH

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Answer of Question (1)

A) 1	2	3	4	5	5
b	b	d	b	a	a

B) 1.

$$\begin{matrix} CH_2\text{-}OH \\ | \\ CH\text{-}OH \\ | \\ CH_2\text{-}OH \end{matrix} \quad +\ 3HNO_3 \quad \xrightarrow{\text{Conc. } H_2SO_4} \quad \begin{matrix} CH_2\text{-}O\text{-}NO_2 \\ | \\ CH\text{-}O\text{-}NO_2 \\ | \\ CH_2\text{-}O\text{-}NO_2 \end{matrix} \quad +\quad 3H_2O$$

Phenol $+ 3HNO_3 \xrightarrow{\text{Conc. } H_2SO_4}$ (Picric acid) $+ 3H_2O$

2.

$$C_2H_5OH \xrightarrow[180^{0}C]{\text{Conc.}H_2SO_4} C_2H_4 + H_2O$$

$$C_2H_4 + H_2O + [O] \xrightarrow[\text{Alkaline medium}]{KMnO_4} C_2H_4(OH)_2$$

3.

$$CH_3 - \underset{\underset{CH_3}{|}}{C} = CH - CH_3 \quad +\ H_2O \quad \xrightarrow{H_2SO_4} \quad CH_3 - \underset{\underset{OH}{|}}{\overset{\overset{CH_3}{|}}{C}} - CH_2 - CH_3$$

2-methyl -2- butanol

C) Ethanol – ethylene glycol – glycerol – sorbitol

D) 1- Compound (A) is an alcohol as ethanol C_2H_5OH
- Compound (B) is an organic acid as acetic acid CH_3COOH

2. $CH_3COOH + C_2H_5OH \xrightarrow{\text{Conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$

Ethyl acetate

Answer of Question (2)

A) 1. Basicity of acids   **2.** Carbohydrates
3. estrification (ester formation)   **4.** Primary alcohol

B) 1. Acetone from iso-propanol:

$$\underset{\text{Iso-propanol}}{\underset{CH_3}{\overset{CH_3}{>}}CHOH + [O]} \xrightarrow[\text{Conc. } H_2SO_4]{KMnO_4} \underset{\text{Acetone}}{\underset{CH_3}{\overset{CH_3}{>}}C=O + H_2O}$$

2. Phenol from benzene:

$$C_6H_6 + Cl_2 \xrightarrow[\text{I.S.L}]{FeCl_3} C_6H_5Cl + HCl$$

$$C_6H_5Cl + NaOH \xrightarrow[\text{300 Atmospheres}]{300^{0}C} C_6H_5OH + NaCl$$

Benzene from Phenol:

$$C_6H_5OH + Zn \xrightarrow{\text{Heat}} ZnO$$

3. Acetic acid from calcium carbide:

$$CaC_2 + 2H_2O \xrightarrow[\text{HgSO}_4 / 60^{0}C]{H_2SO_4\ 40\%} C_2H_2 + Ca(OH)_2$$

$$C_2H_2 + H_2O \xrightarrow[\text{HgSO}_4 / 60^0\text{C}]{\text{H}_2\text{SO}_4\ 40\%} CH_3CHO$$

$$CH_3CHO + [O] \xrightarrow[\text{Conc. H}_2\text{SO}_4]{\text{KMnO}_4} CH_3COOH$$

4.

$$C_2H_2 + H_2O \xrightarrow[\text{HgSO}_4 / 60^0\text{C}]{\text{H}_2\text{SO}_4\ 40\%} CH_3CHO + H_2O$$

$$CH_3CHO + [O] \xrightarrow[\text{Conc. H}_2\text{SO}_4]{\text{KMnO}_4} CH_3COOH$$

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

$$CH_3COONa + NaOH \xrightarrow[\Delta]{\text{CaO}} CH_4 + Na_2CO_3$$

C)1. Experiment	Ethanol	Phenol
By adding $FeCl_3$ solution to each of them	No effect	A violet colour is formed

2. Experiment	Carbolic acid	Ethanoic acid
By adding Na_2CO_3 solution to each of them	No effect	Effervescence takes places and CO_2 evolves which turbids lime water

Answer of Question (3)

A) 1. Primary alcohols are (1-propanol) and (2-methyl-1- propanol)

2. Secondary alcohol is (2-propanol)

3. Phenols is (catechol)

4. Alcohol which gives aldehydes on oxidation are (1-propanol) and (2-methyl-1-propanol)

5. Alcohol which gives ketones on oxidation is (2-propanol)

6. Product of nitration of phenol is (picric acid)

7. Disubstituted benzene is (catechol)

8. Tetra substituted is (picric acid)

B) compound	Its use
1. Ethylene glycol	Antifreeze substance in car radiators in cold countries.
2. Glycerol	Manufacture of creams and cosmetics - explosives.
3. Picric acid	Explosives - treatment of burns.
4. Ethanol	used in manufacture of perfumes and alcoholic liquors.
5. Phenol	- used as a starting material for many industrial products such as: 1.Polymers 2. Dyes 3. Salicylic acid derivatives.
6. Bakelite	used in manufacturing some electrical instruments and ash trays.

C) 1.

$$C_2H_4 + H_2O \xrightarrow{\text{H}_2\text{SO}_4} C_2H_5OH$$

$$2C_2H_5OH \xrightarrow[140^0\text{C}]{\text{Conc. H}_2\text{SO}_4} C_2H_5 - O - C_2H_5 + H_2O$$

2.

$$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + CO_2 + H_2O$$

$$CH_3COONa + NaOH \xrightarrow[\Delta]{\text{CaO}} CH_4 + Na_2CO_3$$

$$CH_4 + Cl_2 \xrightarrow{\text{Indirect sunlight}} CH_3Cl_, + HCl$$

$$CH_3Cl + KOH(aq) \xrightarrow{\text{Heat}} CH_3OH + KCl$$
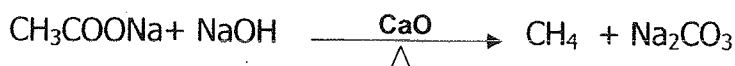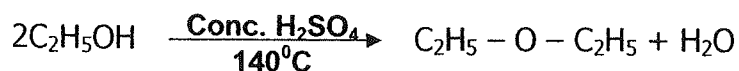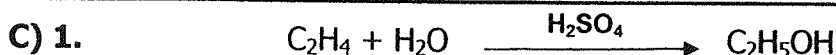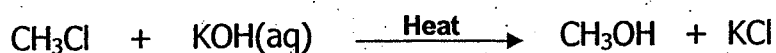
Answer of Question (4)

A) 1.

The structural formula of ethanol	The structural formula of dimethyl ether

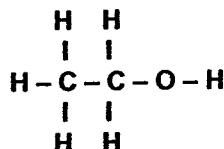$$\begin{array}{c} \quad H \quad H \\ \quad | \quad | \\ H-C-C-O-H \\ \quad | \quad | \\ \quad H \quad H \end{array} \qquad\qquad \begin{array}{c} \quad H \quad\quad H \\ \quad | \quad\quad | \\ H-C-O-C-H \\ \quad | \quad\quad | \\ \quad H \quad\quad H \end{array}$$
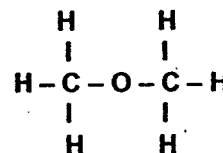
2. Conversion of ethanol into diethyl ether: giving ether.

$$\left.\begin{array}{c} C_2H_5\;O\;H \\ \\ C_2H_5\;OH \end{array}\right\} \xrightarrow[140\,^0C]{\text{Conc. } H_2SO_4} C_2H_5-O-C_2H_5 + H_2O$$
$$\text{Diethyl ether}$$
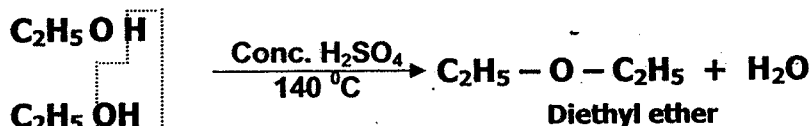
3. obtaing hydrogen from diethyl ether:

$$2C_2H_5OH + 2Na \longrightarrow 2C_2H_5ONa + H_2 \text{ (burns with a pop sound)}$$
$$\text{(Sodium ethoxide)}$$

B) 1.
$$C_2H_5OH \xrightarrow[180\,^0C]{\text{Conc. } H_2SO_4} C_2H_4 + H_2O$$
$$\text{Ethene}$$

2.
$$2\,C_2H_5\,O\,H \xrightarrow[140\,^0C]{\text{Conc. } H_2SO_4} C_2H_5-O-C_2H_5 + H_2O$$
$$\text{Diethyl ether}$$

3.

(phenol) + $3HNO_3$ $\xrightarrow{\text{Conc. } H_2SO_4}$ (Picric acid) + $3H_2O$

4.
$$\begin{array}{c} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array} + 3HNO_3 \xrightarrow{\text{Conc. } H_2SO_4} \begin{array}{c} CH_2\text{-}O\text{-}NO_2 \\ | \\ CH\text{-}O\text{-}NO_2 \\ | \\ CH_2\text{-}O\text{-}NO_2 \end{array} + 3H_2O$$
$$\text{Glycerol} \qquad\qquad\qquad\qquad \text{Trinitroglycerine}$$
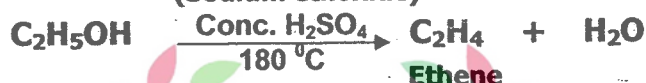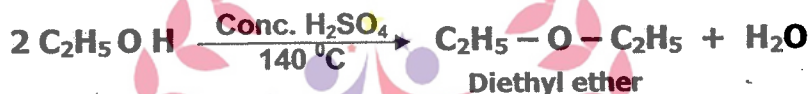
C) 1. This is because the benzene ring in phenol decreases the strength of O-H bond. This facilitates the separation of (H^+) ions while the alkyl group in alcohols increases the polarity of (- OH) and becomes difficult to separate (H^+) ions
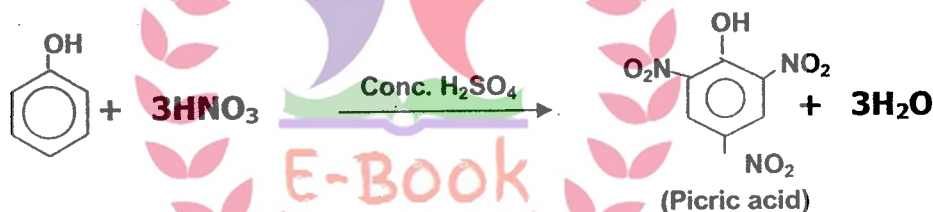
2. To absorb the resulting water, and prevents the reversible reaction.

3. This is due to the presence to one carboxylic group in benzoic acid and two carboxylic groups in oxalic acid.

4. Ethanol does not react with sodium hydroxide due to the presence of alkyl group which decrease the length of [O-H] bond and becomes difficult to separate of [H^+], while phenol reacts with sodium hydroxide due to presence of benzene ring which increase the length of [O-H] bond and this facilitates the separation of [H^+].
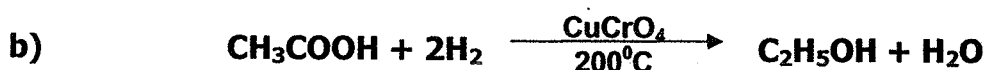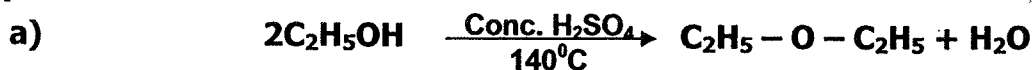
5. This is because bakelite is heat resistant.

6. Because in acids each two molecules are linked together by two hydrogen bonds, so, it needs higher energy to be broken, while in alcohols, each two molecules are linked together with one hydrogen bonds, so it needs lower energy to be broken.

A) 1,2,3

Symbol	functional group	Its name	Class	example
(A)	- OH	Hydroxyl group	alcohols	ethanol
(B)	- O -	Ether group	ethers	Dimethyl ether
(C)	- CHO	Aldehyde group	aldehydes	acetaldehyde
(D)	- COOH	Carboxylic group	Carboxylic acids	Carboxylic acid

4.

a) $$2C_2H_5OH \xrightarrow[140^0C]{Conc.\ H_2SO_4} C_2H_5 - O - C_2H_5 + H_2O$$

b) $$CH_3COOH + 2H_2 \xrightarrow[200^0C]{CuCrO_4} C_2H_5OH + H_2O$$

c) $$CH_3CHO + H_2 \xrightarrow[Heat]{Ni} CH_3COOH$$

d) $$C_2H_5OH + [O] \xrightarrow[Conc.\ H_2SO_4]{KMnO_4} CH_3CHO + H_2O$$

The structural formula for:

1. Dicarboxylic aromatic acid $C_8H_6O_4$
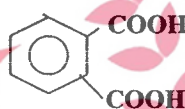
Phthalic acid

2. Dicarboxylic aliphatic acid $C_2H_2O_4$

COOH
|
COOH

Oxalic acid

3. Aliphatic ether $C_4H_{10}O$
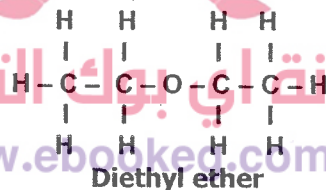
Diethyl ether

4. Three alcohols having the molecular formula $C_5H_{12}O$
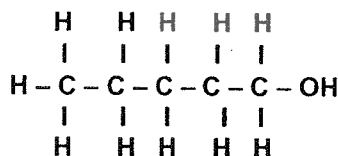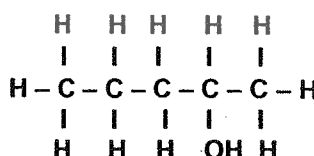
1- Pentanol   2- Pentanol   3 - Pentanol

C) 1. Catechol.

2. ethylene glycol.

D) Arrangement of the compounds in ascending order with respect to increase in their acidity:

CH_3OH < (phenol OH) < CH_3COOH < (benzoic COOH) < HCl
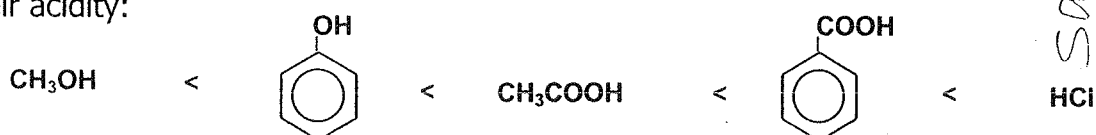
Answer four only of the following questions

Question (1)

A) Choose the correct answer:

1. Sulphonation reaction of aromatic benzene ring is ....reaction.
   a- oxidation.   b- addition.   c- substitution.   d- elimination.

2. Isopropyl alcohol (2-propanol) is ....alcohol.
   a- primary.   b- secondary.   c- dihydric.   d- tertiary.

3. The number of hydrogen atoms in the alkane molecule which consists of 4 carbon atoms is ....atoms.
   a- 5.   b- 10.   c- 7.   d- 8.

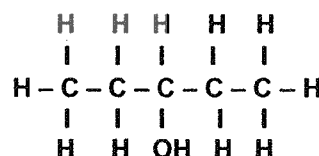4. Addition of drops of iron (III) Chloride solution to the phenolic water solution gives..........
   a- violet colour.   b- brown colour.   c- yellow colour.   d- orange colour.

5. When sodium benzoate is heated with soda lime, the product is ....
   a- benzoic acid.   b- toluene.   c- benzene.   d- benzaldehyde.

6. When hydrobromic acid reacts with propene .... is produced.
   a- propyl bromide.   b- 1,2 dibromopropene.   c- 2-bromopropane.   d- 1-bromopropane.

B) How can you obtain:

1) Ethanol from petroleum products.
2) Ethanol from ethyl bromide and vice versa.
3) Ethanol from ethylene and vice versa.
4) Acetone from isopropanol.
5) Benzene from phenol and vice versa.

C) Compare between each pair of the following:

1) Organic compounds and inorganic compounds.
2) Addition and polymerization condensation polymerization.
3) Acidity of alcohols and acidity of phenols.
4) Acid hydrolysis and alkaline hydrolysis of esters.

Question (2)

A) Write the Scientific expression for each of the following:

1) Easy liquefied halogenated alkanes used in manufacture of cooling systems.
2) Addition of water to alkenes or alkynes in the presence of a catalyst.
3) Conversion of long chain hydrocarbons to a shorter one by the effect of heat, pressure and catalyst.
4) Polyhydroxy aldehydes or polyhydroxy ketones.
5) Reaction of ester with ammonia to give an acid amide and alcohol.
6) The number of carboxylic acid in an organic acid.

B) If you given the following table:

Formic acid	Ethanoic acid	Oxalic acid
Salicylic acid	Butyric acid	Benzoic acid

From the previous table mention the following:

1- Monocarboxylic acid.

2- Dicarboxylic acid.

3- An acid in which the number of carboxylic groups equals the number of carbon atoms.

4- An acid contains two functional groups.

C) "A, B, C and D are four functional groups"

(-OH)	(-O-)	(-CHO)	(-COOH)
(A)	(B)	(C)	(D)

1) Write the name of each functional group. .

2) What is the class of the compounds having a functional group from them?

3) Give an example for an organic compound having a functional group from them.

4) Show by chemical equation how to convert an organic compound having the functional group:

a) (A) to another having a functional group (B)

b) (D) to another having a functional group (A)

c) (C) to another having a functional group (A)

d) (A) to another having a functional group (C)

5) What is the result of reaction of a compound has the function group of (A) with a compound has the function group of (D)? What is the name of this reaction?

Question (3)

A) Give reasons for:

1) The presence of a huge number of organic compounds.

2) Ethanol and dimethyl ether are isomers.

3) Alkanes, alkenes and alkynes form homologous series.

4) Ethyne gas is passed in copper sulphate solution before collecting it.

5) Cyclopropane is more reactive than normal propane.

6) Boiling point of carboxylic acids is higher than that of the corresponding alcohols which have the same number of carbon atoms.

B) From the following substances or some of them:

Calcium carbide - distilled water - sulphuric acid 40% - ethyl acetate - mercury (II) sulphate – ammonia gas – red hot nickel tube - Bunsen flame.

Show by balanced chemical equations how you can obtain the following compounds:

1- Acetaldehyde   2- Acetamide   3- Benzene

C) What happens in the following cases:

1) Ammonium chloride reacts with silver nitrate and then heating the product.

2) Dry distillation of sodium acetate with soda lime.

3) Thermal catalytic cracking of octane.

Question (4)

A) How can you differentiate between each pair of the following:

1) Methane and ethene.   2) Ethanol and phenol.

3) Carbolic acid and acetic acid   4) Ethanol and 2- Methyl – 2- butanol.

B) 1. Arrange the following steps to obtain picric acid from calcium carbide.

(polymerization-hydrolysis-dropping-halogenation-nitration)

2. Arrange the following steps to obtain T.N.T from calcium carbide.

(polymerization-nitration-alkylation-dropping)

C) Give reasons for:

1) Benzoic acid is monobasic whereas Phthalic acid is a dibasic one.
2) Cone. Sulphuric acid is added in ester formation and nitration.
3) Citric acid is added to frozen fruits.
4) Doctors' advice to crush the aspirin tablet as a powder before swallowing or taking it dissolved in water.

Question (5)

A) "Saturated open chain hydrocarbon having 17 atoms in its structure"

1. What is the number of carbon and hydrogen atoms in this compound?
2. Write the molecular formula of this hydrocarbon.
3. Write the expected structural formulae, and then name each one according to IUPAC system.

B) 1. How is methane gas prepared in the laboratory? Draw the apparatus used. And write the equation of reaction.

2. Show by symbolic equation the product of passing a mixture of water vapour and methane gas at 725°C in the presence of a catalyst. What is the name of the product?

C) Write the symbolic equations to explain what is meant by each of the following:

1. Fridel Carft's reaction for preparation of toluene.
2. Baeyer's reaction for preparation of ethylene gygol.

Answer exam (16) on organic chemistry

Answer of question (1)

A)	1	2	3	4	5	6
	c	b	b	a	c	c

B) 1) Ethanol from petroleum products.

$$\text{Petroleum products} \xrightarrow[\text{Catalytic cracking}]{\text{Thermal}} C_2H_4$$

$$C_2H_4 + H_2O \xrightarrow{H_2SO_4} C_2H_5OH$$

2) Ethanol from ethyl bromide and vice versa.

$$\underset{\text{Ethyl bromide}}{C_2H_5Br} + KOH \xrightarrow[\triangle]{\text{Aq.}} \underset{\text{Ethanol (Primary alcohol)}}{C_2H_5OH} + KBr$$

$$C_2H_5OH + HCl \xrightarrow{ZnCl_2} C_2H_5Cl + H_2O$$

3) Ethanol from ethylene and vice versa.

$$C_2H_4 + H_2O \xrightarrow{H_2SO_4} C_2H_5OH$$

$$C_2H_5OH \xrightarrow[180\,\text{C}]{\text{Conc.}H_2SO_4} C_2H_4 + H_2O$$

4) Acetone from isopropanol.

$$CH_3\text{-}CHOH + [O] \xrightarrow[\text{Conc. } H_2SO_4]{KMnO_4} CH_3\text{-}C=O + H_2O$$

2- Propanol (sec. alcohol)   Acetone (Propanone)

5) Benzene from phenol and vice versa.

Phenol + Zn $\xrightarrow{\text{Heat}}$ Benzene + ZnO

Benzene + Cl_2 $\xrightarrow[\text{I.S.L}]{FeCl_3}$ (chlorobenzene) + HCl

(chlorobenzene) + NaOH $\xrightarrow[\text{300 Atmospheres}]{300\,^\circ C}$ (phenol) + NaCl

C) 1.
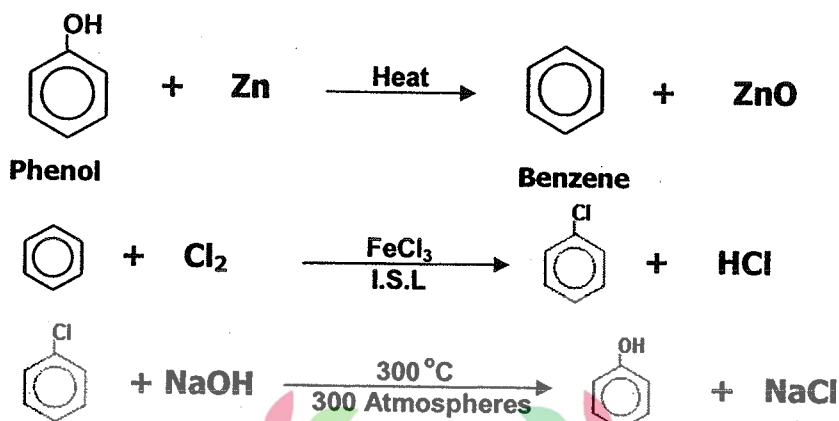
Property	Organic compounds	Inorganic compounds
1-Chemical structure	Mainly contain carbon atoms.	May contain carbon atoms in addition to other elements.
2-Solubility	most are Insoluble in water but soluble in organic solvent as benzene	most are soluble in water
3-Melting point	low.	high
4-Boiling point	low.	high
5- The odour	Most have characteristic odour.	most are odourless
6-Inflammability	inflammable and produce CO_2, H_2O	not inflammable, if it is inflammable it produces other gases
7-Kinds of bonds in the molecule	covalent bonds	Ionic bonds
8-Conductivity	Do not conduct electricity.	usually electrolytic compounds conduct electricity
9-Rate of chemical reaction	slow, because it takes place between the molecules	Fast, because it takes place between the ions.
10-Polymerization	can be polymerized	can't be polymerized
11-Isomerism	It is found among many compounds	not found among their compounds.

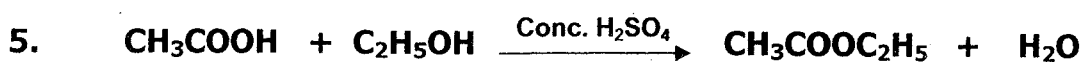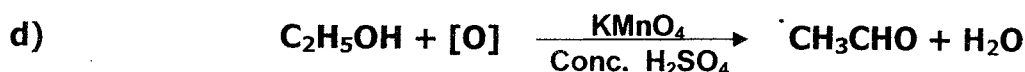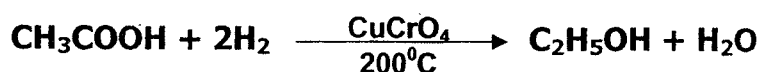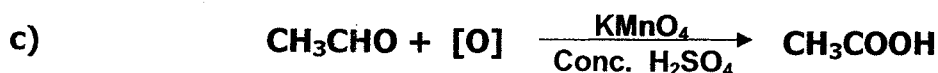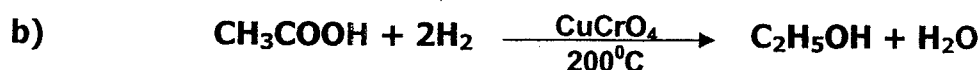| 2. Addition polymerization	Condensation polymerization
Combination of a large number of unsaturated simple molecules (monomers) to give a giant molecule (polymer) having the same empirical formula.(e.g. Ethylene glycol)	Condensation of two different monomers to give a new monomer called copolymer which undergoes polymerization (e.g. Dacron)

3.	Acidity of alcohol	Acidity of phenol
	1. Alcohols are less acidic than phenols because the alkyl group decreases the length of bond between oxygen and hydrogen atom in (O-H) group and this makes the separation of H^+ ions is more difficult.	1. Phenols are more acidic than alcohols because the aryl group increases the length of bond between oxygen and hydrogen atom in (O-H) group and this makes the separation of H^+ ions is easier.
	2. Alcohols react with active metals such as sodium but do not react with NaOH.	2. Alcohols react with active metals such as sodium and react with NaOH.

4.	Alkaline hydrolysis of esters	Acidic hydrolysis esters
	1. Hydrolysis of ester in presence of aqueous alkali e.g.(aqueous NaOH)	1. Hydrolysis of ester in presence of dilute mineral acid e.g.(H_2SO_4)
	2. Gives an alcohol and the salt of the acid.	2. Gives an alcohol and organic acid.
	3. Example:	3. Example:
	$CH_3COOC_2H_5 + NaOH \longrightarrow CH_3COONa + C_2H_5OH$	$CH_3COOC_2H_5 + H_2O \xrightarrow{H^+} C_2H_5OH + CH_3COOH$

Answer of question (2)

A) 1. Freons. 2. Catalytic hydration.
3. Thermal catalytic cracking. 4. Carbohydrates.
5. Ammonolysis. 6. Basicity of acid.

B) 1. Monocarboxylic acids are:
Formic acid, Ethanoic acid, Salicylic acid, Butyric acid and Benzoic acid.
2. Dicarboxylic acid is oxalic acid.
3. Formic acid and oxalic acid.
4. Salicylic acid

C) 1,2,3

Symbol	functional group	Its name	Class	Example
(A)	- OH	Hydroxyl group	alcohols	ethanol
(B)	- O -	Ether group	ethers	Dimethyl ether
(C)	- CHO	Aldehyde group	aldehydes	acetaldehyde
(D)	- COOH	Carboxylic group	Carboxylic acids	Acetic acid

4. a) $2C_2H_5OH \xrightarrow[140^0C]{Conc.\ H_2SO_4} C_2H_5 - O - C_2H_5 + H_2O$

b) $CH_3COOH + 2H_2 \xrightarrow[200^0C]{CuCrO_4} C_2H_5OH + H_2O$

c) $CH_3CHO + [O] \xrightarrow[Conc.\ H_2SO_4]{KMnO_4} CH_3COOH$

$CH_3COOH + 2H_2 \xrightarrow[200^0C]{CuCrO_4} C_2H_5OH + H_2O$

d) $C_2H_5OH + [O] \xrightarrow[Conc.\ H_2SO_4]{KMnO_4} CH_3CHO + H_2O$

5. $CH_3COOH + C_2H_5OH \xrightarrow{Conc.\ H_2SO_4} CH_3COOC_2H_5 + H_2O$
This reaction is called estrification.

A) 1. Due to the ability of carbon atoms to combine with each other or with other atoms by different types of bonds, through straight chains, branched chains, cyclic and aromatic compounds.

2. Because they are different in the physical and chemical properties and also in structural formula but they have the same molecular formula.
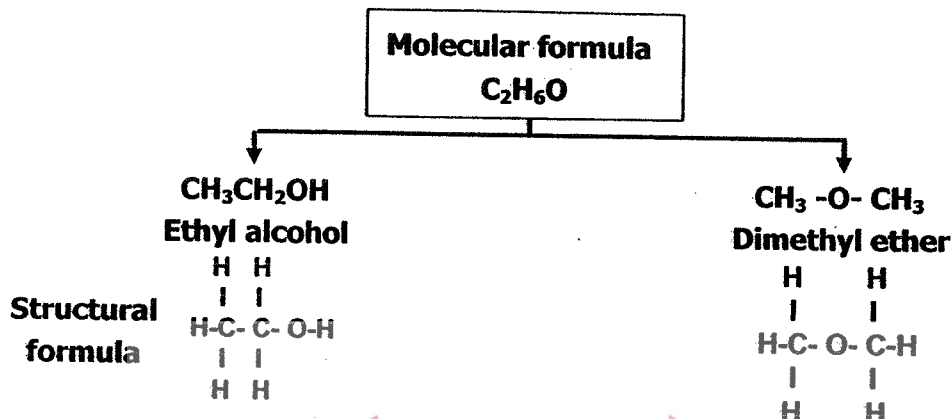
3. Because each series is a group of compounds that have the same molecular formula, chemical properties and graduated physical properties.

4. To remove phosphine gas (PH_3) and hydrogen sulphide (H_2S), which are produced from the impurities found in calcium carbide.

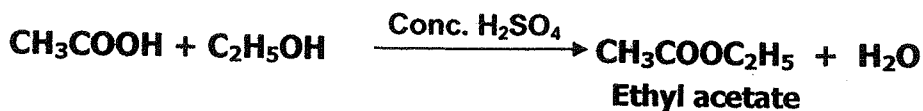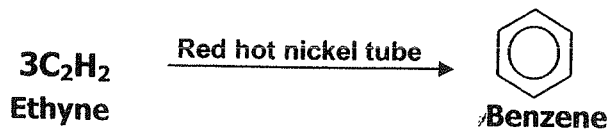5. This is because the value of angles between bonds in cyclopropane is lower than 109° which leads to weak overlapping between orbitals.

6. Because in acids each two molecules are linked together by two hydrogen bonds, so, it needs higher energy to be broken, while in alcohols, each two molecules are linked together with one hydrogen bonds, so it needs lower energy to be broken.

B) 1. Obtaining acetaldehyde:

$$CaC_2 + 2H_2O \xrightarrow{\text{Dropping}} C_2H_2 + Ca(OH)_2$$

$$C_2H_2 + H_2O \xrightarrow[\text{HgSO}_4 / 60°C]{H_2SO_4 \ 40\%} CH_3CHO$$

2. Obtaining acetamide:

$$CH_3CHO + [O] \xrightarrow[\text{Conc. } H_2SO_4]{KMnO_4} CH_3COOH$$
Acetic acid

$$CH_3COOH + C_2H_5OH \xrightarrow{\text{Conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$$
Ethyl acetate

$$CH_3COOC_2H_5 + NH_3 \longrightarrow CH_3CONH_2 + C_2H_5OH$$
Acetamide

3. Obtaining benzene:

$$3C_2H_2 \xrightarrow{\text{Red hot nickel tube}}$$
Ethyne   **Benzene**

C) 1.

$$NH_4Cl + AgCNO \longrightarrow AgCl + NH_4CNO$$

           Silver cyanate   **ammonium cyanate**

$$NH_4CNO \xrightarrow{\Delta} H_2N-CO-NH_2$$

   (Ammonium cyanate)   **(Urea)**

2.

$$CH_3COONa + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$

3.

$$C_8H_{18} \xrightarrow[\text{Catalyst}]{\text{Pressure / temp.}} C_4H_8 + C_4H_{10}$$

                                            Butene   **Butane**

Answer of question (4)

A) 1.

Experiment	Methane gas	Ethene (ethylene) gas
a) By adding bromine dissolved in (CCl_4) to each of them.	No effect	The red colour of bromine disappears
b) By adding $KMnO_4$ in an alkaline medium to each of them	No effect	The violet colour of $KMnO_4$ disappears.
$C_2H_4 + H_2O + [O] \xrightarrow[\text{Alkaline medium}]{KMnO_4} C_2H_4(OH)$ ethylene glycol		

2.

Experiment	Ethyl alcohol (ethanol)	Phenol (picric acid)
By adding $FeCl_3$ solution to each of them	No effect	A violet colour appears.

3.

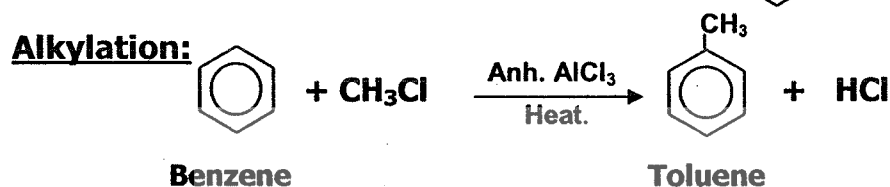| Experiment	Acetic acid	Phenol (Carbolic acid)
By adding Na_2CO_3 solution to each of them	Effervescence takes places and CO_2 evolves which turbid lime water	No effect

4.

Experiment	(Ethanol)	(2- Methyl – 2- butanol)
By adding $KMnO_4$ solution and conc. H_2SO_4 to each of them.	The violet colour of potassium permanganate disappears.	No effect

B) 1. Dropping

$$CaC_2 + 2H_2O \xrightarrow{\text{Dropping}} C_2H_2 + Ca(OH)_2$$

Polymerization: $3C_2H_2 \xrightarrow{\text{Red hot nickel tube}} C_6H_6$

Halogenation: ⬡ $+ Cl_2 \xrightarrow[\text{I.S.L}]{FeCl_3}$ ⬡–Cl $+$ HCl

Hydrolysis: + NaOH $\xrightarrow[\text{300 Atmospheres}]{300\,^{\circ}C}$ + NaCl

Nitration: + $3HNO_3$ $\xrightarrow{\text{Conc. } H_2SO_4}$ + $3H_2O$

(Picric acid)

2. Dropping: $CaC_2 + 2H_2O \xrightarrow{\text{Dropping}} C_2H_2 + Ca(OH)_2$

Polymerization: $3C_2H_2 \xrightarrow{\text{Red hot nickel tube}}$

Alkylation: + CH_3Cl $\xrightarrow[\text{Heat.}]{\text{Anh. } AlCl_3}$ + HCl

Benzene   **Toluene**

Nitration: + 3HN $\xrightarrow{\text{Conc. } H_2SO_4}$ + $3H_2O$

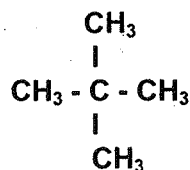**Toluene**   **2, 4, 6 trinitrotoluene (T .N. T)**

C) 1. Because benzoic acid contains one carboxylic group while Phthalic acid contains two groups.

2. To absorb the water produced and prevent the reversible reaction.

3. Because it decreases the pH. Thus, it prevents the growth of bacteria and keeps their colours and taste.

4. Because aspirin is hydrolyzed in the body to produce salicylic acid and acetic acid. The produced acids cause the excitation of stomach walls and may cause stomach ulcer.

Answer of question (5)

A) 1- $n + 2n + 2 = 17$

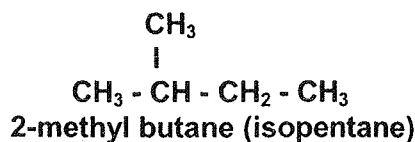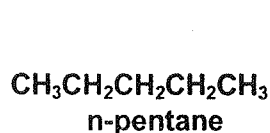 $3n = 17 - 2$

            $3n = 15$

            $n = 5$

Number of C atoms = 5, Number of H atoms = 12
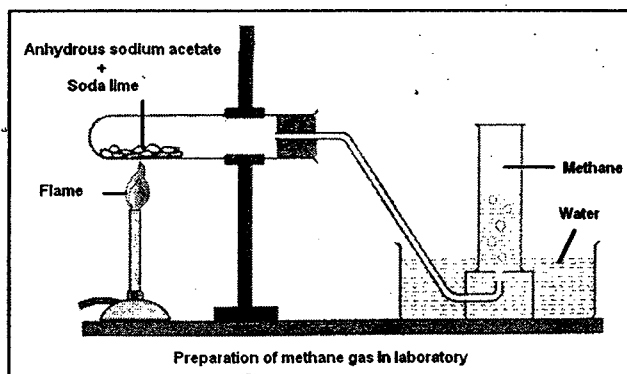
2- Molecular formula is C_5H_{12}

$$CH_3 - \underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}} - CH_3$$

2,2 dimethyl propane (Neopentane)

3- Expected structural formulae:

$CH_3CH_2CH_2CH_2CH_3$ $CH_3 - \underset{\overset{|}{CH_3}}{CH} - CH_2 - CH_3$

n-pentane   **2-methyl butane (isopentane)**

B) 1. Preparation of methane in laboratory:

Preparation of methane gas in laboratory

Equation of reaction:

$$CH_3COONa + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$

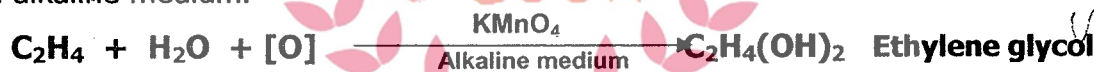2. $CH_4 + H_2O \xrightarrow[\text{Catalyst}]{725\,\dot{C}} CO + 3H_2$ This product is called water gas.
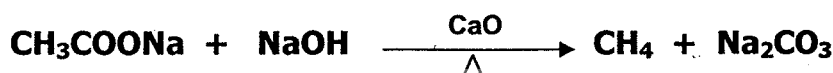
C) 1. Friedel Craft's reaction:
is the reaction of benzene with methyl chloride in the presence of anhydrous aluminum chloride ($AlCl_3$) as a catalyst.

Benzene $+ CH_3Cl \xrightarrow[\text{Heat.}]{\text{Anh. } AlCl_3}$ Toluene (CH_3) $+ HCl$
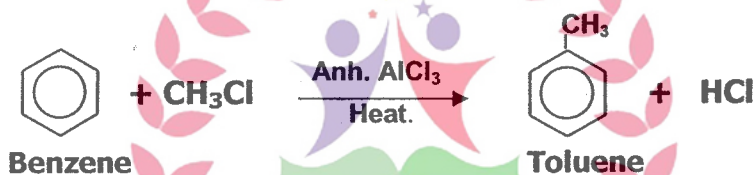
2. Baeyer's reaction
is the reaction between ethene and potassium permanganate in alkaline medium.

$$C_2H_4 + H_2O + [O] \xrightarrow[\text{Alkaline medium}]{KMnO_4} C_2H_4(OH)_2 \text{ Ethylene glycol}$$